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H.R. 4226—RENEWABLE ENERGY AND ENERGY CONSERVATION COMMERCIALIZATION AND DEVELOPMENT ACT

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDREDTH CONGRESS

SECOND SESSION

JUNE 30, 1988

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H.R. 4226—THE RENEWABLE ENERGY AND ENERGY CONSERVATION COMMERCIALIZATION AND DEVELOPMENT ACT

THURSDAY, JUNE 30, 1988

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
Washington, DC.

The Subcommittee met, pursuant to call, at 9:35 a.m., in Room 2325, Rayburn House Office Building, Hon. Marilyn Lloyd (Chairman of the Subcommittee) presiding.

Mrs. LLOYD. The Subcommittee will come to order. Good morning, ladies and gentlemen.

Today we will receive testimony on the bill H.R. 4226, the Renewable Energy and Energy Conservation Commercialization and Development Act, which I introduced with Congressman Phil Sharp on March 22, 1988.

This bill seeks to insure adequate budget levels for the renewable and energy conservation research and development activities within the Department of Energy for three years. While these activities are included in the civilian energy authorization bill for fiscal year 1989, I believe they have suffered more than their fair share of cuts in recent budget considerations.

By introducing H.R. 4226, I hope to put these technologies on a more certain course by research and development to market readiness in a reasonable timeframe. In doing so, I believe the United States will take another step toward keeping its energy options open so as to not narrow our choices.

H.R. 4226 requires DOE to set technical performance goals with industrial participation for renewable technologies. It also requires DOE to propose three renewable energy joint venture demonstration projects which shall be cost-shared on a 50-50 basis by industry. It authorizes three-year funding levels and requests the Department to provide a strategic plan that shows how its research and development programs will achieve the policy goals of the national energy policy plan.

During the past 7½ years, the emphasis of our Federal research and development efforts has shifted to the long-term, high-risk focus, with much of the burden of demonstration placed on the private sector. Cost-sharing of projects has become the norm. Even a few years ago, it seemed improbable that the private sector would step forward with demonstration funding. Indicative of the change of attitude is the Clean Coal Program with a mandated 50-50 cost-

sharing by the private sector. And even with the cost-sharing requirement, the Department received 54 proposals to a recent solicitation.

I believe the large number of respondents shows a clear need and a strong desire by the private sector to demonstrate technologies. Unfortunately, renewable and conservation technologies do not have the benefit of a coherent demonstration program.

Renewable technologies are already making a contribution to our energy supplies. For example, the international market for wind turbines today is roughly 200 million per year, and is expected to rise to 1 billion per year by 1994.

But in the last seven years, the share of the United States wind machine market, captured by foreign imports, has gone from zero to to 70 percent.

The international market for photovoltaics is currently $500 million, and is expected to increase to $5.4 billion by the year 2012.

The implications of the projection for United States technological competitiveness are self-evident. Not only can we look forward to increasing utilization of renewable technologies in the future, but we are currently receiving the benefits of several technology. California has been particularly progressive with 1.7 billion kilowatt hours of wind-generated electricity in 1987, and 1600 megawatts of geothermal capacity on line.

Photovoltaics has found a small market niche in remote applications but needs additional research to compete with the current economics of other electrical generation methods. Energy conservation holds equal promise.

Our successes today have been enormous. On a worldwide basis, one estimate says that energy efficiency now displaces $250 billion worth of oil, gas, coal, and nuclear power annually. Yet, there is additional efficiency left to exploit. Some projections are for the equivalent of a savings of 5 to 18 million barrels of oil per day through efficient improvement.

I am pleased to report that this bill currently has 51 cosponsors. And if time permits in our Congressional schedule, I do intend to mark up the bill at Subcommittee in September.

[The bill, H.R. 4226 follows:]

100TH CONGRESS
2D SESSION

H. R. 4226

To promote the development and commercialization of renewable energy and energy conservation.

IN THE HOUSE OF REPRESENTATIVES

MARCH 22, 1988

Mr. SHARP (for himself and Mrs. LLOYD) introduced the following bill; which was referred jointly to the Committees on Energy and Commerce and Science, Space, and Technology

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A BILL

To promote the development and commercialization of renewable energy and energy conservation.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the "Renewable Energy and Energy Conservation Commercialization and Development Act".

SEC. 2. PURPOSES.

It is the purpose of this Act to—

(1) reaffirm that solar and renewable energy and energy efficiency are essential components of our na-

tional energy policy which can contribute to national security with minimal environmental risk;

(2) enhance the prospects of significant further commercial application of solar and renewable energy and energy efficiency technologies;

(3) enhance and enlarge the market for United States solar and renewable energy and energy efficiency products both at home and in international markets;

(4) provide stable funding for solar and renewable energy and energy efficiency research, development, and commercialization which the private sector is unlikely to accomplish; and

(5) reaffirm the importance of transferring the knowledge gained from these research, development, and commercialization programs so that it is useful to industry.

SEC. 3. TECHNICAL PERFORMANCE GOALS.

(a) SECRETARY TO ESTABLISH GOALS.—The Secretary of Energy, in consultation with industry, shall establish specific technical performance goals for research and development programs of the Department of Energy with respect to photovoltaics, wind, solar thermal, biofuels, solar building and energy systems, ocean energy systems, and geothermal energy.

(b) NATURE OF GOALS.—The initial technical performance goals established under subsection (a) shall be designed to promote significant further commercial applications of the technologies involved by the year 1995, unless the maturity of the technology indicates little or no commercial application potential by such time.

(c) REVIEW AND UPDATE.—The Secretary of Energy shall, in consultation with industry, review and update the technical performance goals established under subsection (a) at least once every two years.

(d) REPORT TO CONGRESS.—The Secretary of Energy shall annually submit a report to the Congress describing the updated goals established under this section and the progress made toward reaching such goals.

SEC. 4. COMMERCIAL DEMONSTRATION PROJECTS.

(a) SELECTION OF PROJECTS.—The Secretary of Energy shall, in the Department's budget request for fiscal year 1990, include funding for at least three commercial demonstration projects involving renewable energy technologies. The purposes of these projects shall be to further the commercial viability of renewable energy technologies, to facilitate cooperation and information transfer between industry and the Department of Energy, and to enhance the international competitiveness of the domestic renewable energy industry. The projects shall be selected, in consultation with

industry, so as to take advantage of the most appropriate technologies which can benefit from commercial integration.

(b) FUNDING.—Fifty percent of the cost of projects proposed under subsection (a) shall be funded by the United States, with 50 percent of such costs being contributed by the private sector. In a case where the Secretary determines that a project is viable, but a contribution of 50 percent funding from the private sector cannot be obtained, the United States may fund up to 66 percent of the costs of such project. If the Secretary is unable to obtain the private funding necessary for a project, the Secretary shall report that fact to the Congress along with a description of efforts undertaken to attract such private funding. Funding requested for projects under subsection (a) shall be in addition to funds requested for ongoing research and development programs of the Department of Energy.

SEC. 5. AUTHORIZATIONS OF APPROPRIATIONS.

(a) RENEWABLE ENERGY.—There are authorized to be appropriated to the Secretary of Energy—

(1) for the Wind Energy Research Program, not to exceed $19,000,000 for fiscal year 1989; $22,000,000 for fiscal year 1990; and $26,000,000 for fiscal year 1991;

(2) for the Photovoltaic Energy Systems Program, not to exceed $43,000,000 for fiscal year 1989;

$45,000,000 for fiscal year 1990; and $50,000,000 for fiscal year 1991;

(3) for the Solar Thermal Energy Systems Program, not to exceed $29,000,000 for fiscal year 1989; $32,000,000 for fiscal year 1990; and $35,000,000 for fiscal year 1991;

(4) for the Biofuels Energy Systems Program, an amount not to exceed $32,000,000 for fiscal year 1989; $35,000,000 for fiscal year 1990; and $40,000,000 for fiscal year 1991;

(5) for the Solar Buildings Energy Systems Program, not to exceed $8,000,000 for fiscal year 1989; $9,000,000 for fiscal year 1990; and $10,000,000 for fiscal year 1991;

(6) for the Ocean Energy Systems Program, not to exceed $5,000,000 for fiscal year 1989; $5,000,000 for fiscal year 1990; and $5,000,000 for fiscal year 1991; and

(7) for the Geothermal Program, not to exceed $35,000,000 for fiscal year 1989; $39,000,000 for fiscal year 1990; and $36,000,000 for fiscal 1991.

(b) CONSERVATION.—There are authorized to be appropriated to the Secretary of Energy—

(1) for transportation energy conservation research and development, not to exceed $58,000,000 for fiscal

year 1989; $64,000,000 for fiscal year 1990; and $70,000,000 for fiscal year 1991;

(2) for industrial energy conservation research and development, not to exceed $42,000,000 for fiscal year 1989; $46,000,000 for fiscal year 1990; and $51,000,000 for fiscal year 1991;

(3) for buildings and community systems energy conservation research and development, not to exceed $52,000,000 for fiscal year 1989; $57,000,000 for fiscal year 1990; and $63,000,000 for fiscal year 1991;

(4) for multisector energy conservation research and development, not to exceed $33,000,000 for fiscal year 1989; $36,000,000 for fiscal year 1990; and $40,000,000 for fiscal year 1991; and

(5) for energy conservation research and development policy and management, not to exceed $1,600,000 for fiscal year 1989; $1,700,000 for fiscal year 1990; and $1,900,000 for fiscal year 1991.

(c) INTERAGENCY WORKING GROUP.—There are authorized to be appropriated for the interagency working group established under section 256(d) of the Energy Policy and Conservation Act (42 U.S.C. 6276(d)), not to exceed $1,500,000 for fiscal year 1989, not to exceed $1,750,000 for fiscal year 1990, and not to exceed $2,000,000 for fiscal year 1991.

SEC. 6. STRATEGIC PLAN.

Each annual submission of the National Energy Policy Plan under title VIII of the Department of Energy Organization Act (42 U.S.C. 7321–2) shall be accompanied by a three-year strategic plan for research, development, demonstration, and commercialization of energy technology, including renewable energy and energy efficiency. Such plan shall address the role of federally assisted research, development, demonstration, and commercialization in the achievement of the national policy goals of the National Energy Policy Plan and shall assess both the level of support for energy research, development, demonstration, and commercialization necessary to achieve these goals and the basis for allocating the support recommended by the President among the available alternatives.

○

Mrs. LLOYD. But before we proceed, I do want to recognize my good friend, my colleague, who contributes so much to this Committee, the Honorable Sid Morrison, the Ranking Republican Member of the Subcommittee, for his opening statement.

Mr. MORRISON. Thank you very much, Madam Chairman.

I am pleased that we are looking at this proposed legislation today. I believe it's important for Congress to show some commitment to the development and commercialization of renewable energy and conservation technologies, and this hearing will provide an excellent opportunity for a variety of folks to exchange views on this important subject.

I have heard criticisms from industry that this Nation's renewable energy and conservation research and development programs are oriented toward long-term goals and there's not enough short-term projects for industry to develop commercial products.

On the other hand, I've also heard the Department of Energy say repeatedly that they don't see anything wrong with their research planning and approach, and that demonstration projects for commercialization should be conducted by industry. This is a conflict we wrestle all the time with in this Subcommittee.

Because the Department of Energy, the research community, and industry must work together to accomplish the goal of commercialization, it is obvious that we need to work on resolving some of these differences, so that we can march on ahead.

One of the purposes of this proposed bill is to provide stable and increasing authorization levels for the renewable energy and conservation R&D programs over the next three years.

I think everybody agrees that stability is a necessary ingredient for maintaining viability of these programs, and this Subcommittee has demonstrated our commitment by adding money to the Administration's request year after year. Unfortunately, the budget is also getting tighter at the same time, and we must find ways to do things better. Joint venture demonstration projects between the Government and industry is a provision that could offer a near-term solution before industry can take over demonstration projects totally.

Madam Chairman, I am delighted to have the opportunity to hear the reaction to this proposed legislation from our distinguished witnesses today, and look forward to again this hearing being a learning process.

Mrs. LLOYD. Thank you very much, Mr. Morrison.

Mr. Hefley, I believe, would like to introduce our first speaker.

Mr. HEFLEY. Madam Chairman, thank you, and Members of the Committee.

I would again like to take this opportunity to introduce Dr. Harold Hubbard, who is Director of the Solar Energy Research Institute.

Responsible for research and solar technologies and the exploration of new ideas in solar energy, SERI is the Nation's leading research laboratory contributing to our renewable energy technology production and needs.

The last decade has seen incredible progress in renewable energy research and technology. These energy systems produced through valuable research activity at SERI have proved to be more and

more efficient and effective. Not only has this research made great strides, but it has come to the point where it is touching our everyday lives. From the solar-powered wristwatch, to the solar-powered calculator, to the systems that run the Coast Guard's remote communications network, SERI has researched and developed a multitude of renewable energy applications. With its more recent research activity, SERI is discovering new applications for wind energy, biofuels, and solar thermal systems.

I feel most fortunate to have this valuable research asset located in my district in Golden, Colorado and would like to work with you, Madam Chairman, to see if at an appropriate time we might not get the whole Committee out there. Maybe most of them have been there, I'm not sure. But if they haven't, I think to go and see firsthand what's being done at that amazing facility would—I think every Member of the Committee would share my excitement and enthusiasm. I stand in absolute amazement every time I go through and see again what they're into.

So at this time I'd like to welcome Dr. Hubbard; if you'll join us at the table. He has been SERI's distinguished director since 1981. Dr. Hubbard is, I feel, one of the world's leading authorities on renewable resources, and we are just, Hub, delighted to have you here today, and enthusiastic about what you have to say.

STATEMENT OF DR. HAROLD M. HUBBARD, DIRECTOR, SOLAR ENERGY RESEARCH INSTITUTE, GOLDEN, CO

Dr. HUBBARD. Thank you, is this live? I guess it is.

Mrs. LLOYD. Dr. Hubbard, you are no stranger to this Committee. We are always happy to see you, and I would like to take you up on the trip. I have been really hoping to we could make the trip to visit your facilities and maybe we can work that out this year.

Dr. HUBBARD. I don't want to imply any criticism to the distinguished Chairwoman but you've said that for a year and a half and we hope you'll find time to come out. [Laughter.]

Mrs. LLOYD. I knew you were going to bring that up. I make a promise, if it's not the end of this year, then we hope to work out the first out of next year.

Dr. HUBBARD. Thank you. I appreciate your interest.

Mrs. LLOYD. If we didn't have these things like campaigns, we could do a lot of things, Dr. Hubbard.

Dr. HUBBARD. Well——

Mrs. LLOYD. And especially they get in the way of doing some of the things that most prefer to do.

Dr. HUBBARD. Why don't we just reelect you by acclamation and let it go at that.

Mr. MORRISON [continuing]. A renewable resource. [Laughter.]

Dr. HUBBARD. Well, anyway, I'm——

Mrs. LLOYD. And we can be replaced, very quickly. [Laughter.]

Dr. HUBBARD. Well, anyway, I'm happy to be here. Having heard your opening statement and Mr. Morrison's opening statement, I don't really think you need me. I probably should just endorse what you've said and gracefully retire. And I am not going to read this whole book. I have submitted for the record a considerably lengthy statement but I would like to summarize it.

Mrs. LLOYD. You may summarize if you wish, and your entire statement will be made a part of our record, Dr. Hubbard.

Dr. HUBBARD. Thank you.

I think my problems have already been elucidated by Mr. Morrison when he pointed out the apparent conflict of between where the Department of Energy is, what he perceives the industry to be, and I'm somewhere in between, and so that means probably by the time I'm through I will have made both sides unhappy. And if that's true, then maybe I will have done it about right.

I think it's a good idea to go back and look at basic principles: what is the energy R&D program all about, and why do we need one—just for purposes of orientation and the issues involved, you've already mentioned to a considerable degree.

There's the overriding issue of energy security necessary to this country and necessary to the world. There is the issue of how does this country maintain scientific leadership. There's the important issue of technological competitiveness and economic vitality. And solar R&D, I think, is pertinent to all of those.

I think it's useful to say what what energy security is, and I've got my own definition. But just so we're on the same wavelength I'd like to repeat that if I might. World energy security requires that all nations have assured access to sufficient energy at reasonable cost to sustain their economic growth, to foster their national security, to maintain or improve their standard of living, to protect their environment and public health.

There was a meeting by the National Academy of Engineering in California about three or four weeks ago to look at the energy agenda for the 1990's, and there was a considerable amount of agreement—disagreement—but we agreed at least on a couple of things, and that is, that energy is essential to the future, and that is that the other end is that the energy future is essentially uncertain.

Well, if you look at the conditions for energy security and say how we're going to achieve them, that's not small challenge to a world that's facing increasing its use of fossil fuels; increasing energy demand; the looming menace of the greenhouse effect, which we've heard so much about lately; public suspicion of nuclear power, and a whole collection of things that make the future uncertain. And certainly solar R&D is relevant and pertinent to that.

In your letter of invitation, you outlined some three or four things you wanted me to address. Would a three-year authorization be beneficial? The answer to that is unequivocally yes, because it tends towards stability.

You asked about the impact of stable funding. You asked could insured industry cost-share proposals to bring technologies to commercialization.

And then you asked the one that's guaranteed to get me into trouble, which technologies are closest to commercialization?

Let me try to give you some reasonable answer on all of those.

Certainly, stable and consistent multiyear funding would be critically important to us. If you look at the history of the renewable energy program, the biggest obstacle to an effective and efficient program has been in the relatively erractic nature of the funding.

A senior official in the Department of Energy said to me the other day, the biggest obstacle to industry/Government cost-shared commercialization projects is that the Government is a notoriously unreliable partner, because the resources——

Mrs. LLOYD. I said that—excuse me—the Federal Government in every area, the international partners; I said this in the defense communities, we have a lack of credibility in so many areas, particularly policy.

Dr. HUBBARD. It's unhappy but it's the general perception in industry. And it's a problem for us as we try to develop cooperative programs.

Mrs. LLOYD. The perception is reality.

Dr. HUBBARD. Well, if you look at the history in the late 1970's, there was really too much money, too fast, too soon; it ramped up at a rate in which the funds just could not be effectively used. Now, furthermore, there wasn't emphasis on demonstration programs at that point. In my view, in retrospect, it was was excessive. Demonstration programs too soon put technology into place before it is developed to the point where it will be dependable. Not only does it cost you money—and substantial amounts of money—it ends up with giving the whole technology a black eye. So there's a substantial number of examples of solar technology that were commercialized too soon and really had a negative effect on the reputation—an undeservedly negative effect on the reputation of potential of solar technology.

Then we went to the other extreme; we cut back the program very, very drastically. When you do that at that rate, you can't take advantage of what you've already invested because you can't phase down in a systematic kind of a way. And having gone from a demonstration program that was too aggressive, we went to one that backed us too far away from industry, in my view. So that there was a tendency for industry to lose contact with what went on in the laboratories. I think now we are coming back to some kind of balance.

So stable funding would stabilize the program; it could revitalize the program to a considerable degree; it would encourage industry participation.

I would like to give you a specific example of the problems an R&D manager faces under the current situation in trying to plan a stable program. And I'd like to take the specific example of biofuels. You don't hear as much about biofuels sometimes as you do about photovoltaics and wind, but biofuels really is the largest resource in an all-solar program. It has the largest potential. It also has some of the most significant and challenging underlying scientific challenges, and much of its return is long term, although some of it's fairly immediate.

Looking at what has happened to biofuels funding in the last few years—1987, $24 million. That was phased down just slightly from preceding years, and we get to keep the program fairly stable at SERI up to that point. And then relatively suddenly from our point of view, because we anticipated stability, funding went to $17 million in 1988. We were able, by careful planning and by using carryover funds, and assuming that the program had stabilized at that level or come back a little bit, to sustain that with minimal

damage to the program. We had anticipated, therefore, that there would be stable funding 1988 to 1989. That seemed to be the early indications, and up until about a week ago that's what we expected—and now it would appear that the funding will be down another 25 percent or so, which we had not anticipated.

And when I left the laboratory, the jurisdictional manager for that program told me he didn't know what the impact would be; he was preparing for a catastrophic scenario. Now, that's really unhappy, because we have this program planned on a 10- to 20-year time base. There're some immediate returns that are coming out of the program but the ultimate potential is long term, and the ultimate and complexity of the scientific challenges are long term—and we simply can't do that very well if we can't plan a stable program.

We are the lead laboratory for biofuels conversion. Oak Ridge is the lead laboratory for biofuels supply; and so it's disruptive to us. Not only is that an institutional problem, but it's a problem for the program, period. And so stable funding would help us make real progress towards liquid and gaseous fuels.

But in 1980, if we took what we knew and projected costs for liquid fuels from biofuels then—$5 to $6 a gallon. If we do that today, it's about $1.50 a gallon. Still much too high. Our expectation is that in the time frame of 1995 to 2000, assuming there's a stable program, we can get that down to 80 cents or 90 cents. I can't absolutely guarantee that, but the current experience and learning curve would say that we should be able to do it. The program goes up and down on this subject to functions and funding we cannot really guarantee that level of progress.

It has immediate spinoffs technology because we get into the details of biogenetic modification of enzymes and yeasts, and we are beginning to see spinoffs out of that. It has implications with respect to conservation because we're finding that not only can we make energy fuels out of biofuels but we can produce specialty chemicals and plastics that would replace petrochemicals and would make for more efficient industry. And there are the fundamental questions and investigations of photosynthesis are underlined.

So it's a particularly fruitful program. And it has been very difficult to do that in an optimal kind of a fruitful way.

You asked should cost-share joint ventures be increased. I like the language in the letter to me because you talked about cost-shared projects designed for commercialization—somewhat different language than demonstration projects. Semantics is always a kind of a difficult area, but cost-shared projects aimed at commercialization I like better than demonstration. Demonstration implies to most people setting technology out in the field to prove that it has already arrived. If you do that with technology because it has in fact arrived, you will retard commercialization, not aid it.

If, on the other hand, you put together a cost-shared program aimed at commercialization as we have done in the area of photovoltaics, then I think it can be very useful, indeed, because a cost-shared commercialization program can add to the knowledge base; it can take research from proof-of-concept into the applied and

practical phases; and it can help manufacturers overcome basic stumbling blocks.

Amorphous silicon program, which I talked to you about before, I think is an excellent example of that. We have a joint development program designed at overcoming the manufacturing roadblocks, and it's cost-shared. We started that out with a three-year initiative in 1984 to 1987 at about $18 million and industry cost-shared 30 percent of it. That was successful; it moved things along—not to the point that we can meet our cost goals or efficiency goals, but in that direction.

We then built on that and we went to a proposed *$40 million* program—50 percent cost-shared. And that has moved along well, too. However, given current funding constraints, we are having to phase that program back.

There's a classic tension here. PVUSA is an important program. It's a program with a lot of merit. It's more in the classical demonstration kind of a mode. You do have to have those kinds of projects if utilities are going to use PV because they have to have hands-on experience—so it's a highly desirable program.

On the other hand, if you're interested in developing PV commercially and moving it along and staying ahead of the Japanese, and you had to choose between funding that program and funding a development program that will aid and abet the manufacturing industry, the aid to the manufacturing industry is more important. And that sounds more like a commercialization project to me. I'm just trying to illustrate how the language implies difference, at least if you get into the field.

We have several other examples of what I would call cooperative cost-shared programs; two of them in biofuels, for example. We've had a program going jointly—and it has been difficult to maintain it—between the Colorado School of Mines and Hazen Research Laboratory and a couple of small companies to commercialize a biomass gasifier. That was actually patented in 1982. It received an IR-100 Award in 1982. And we have been trying to help the industry move that into a commercialization ever since. It has gone very, very slowly because it has been difficult to fund it. I think we now have it to the point where there will be two pilot programs—two commercial-scale gasifiers in action in 1989. That was retarded because five or six years ago we simply didn't have the funds for joint-shared commercialization projects or demonstration projects. We could have moved that much faster.

We have a different example now of a small-scale successful program. In the biofuels program, one of the things you do is the pyrolysis of biomass. We do that because we're interested in liquid and gaseous fuels, and the process of doing that was solar energy research funds. We developed what we call a vortex reactor. And we don't need to talk about vortex reactors, but that came out of the biofuels program.

It turned out that in investigating the pyrolysis of biofuels we found a high molecular weight fraction which didn't look to us like it was going to be good for fuels but which we thought could be a feed material for commercialized projects.

We then went to the people on the conservation side that have the ECUT program and said, "Well, we think we've got an ap-

proach here which could be used to replace petroleum base products in industry and which would aid and abet the efficiency of the wood products industry in utilizing the raw material."

Conservation put some money into that and now we have a cooperative program going—a relatively small program—in which we have, Boise Cascade, Borden Adhesives, Gaylord Chemicals, Weyerhaeuser, and several others who are now cost-sharing that program with us. And very shortly, they will be paying about 60 percent of the research. So that's the kind of a cost-shared joint venture that I think makes an awful lot of sense.

You asked what renewable technologies are closest to commercialization, and what needs to be done to bring them to the marketplace. That's really a difficult issue to deal with, because there are many technologies that are all in different kinds of circumstances, and they have both short-term and long-term commercial possibilities—direct combustion of wood, direct combustion in municipal waste, geothermal, hydropower—pretty nearly commercial now are scaled up now. Passive buildings, domestic hot water heating fairly nearly commercial, although in passive buildings it's a problem of providing design tools to the industry and getting the information out.

There's a research problem in that we need to do better modeling. So while it is commercial now and cost-effective now, it still has a significant long-term research element in it. And what we call the emerging technology, some of which you've already mentioned—photovoltaics and wind. Wind is now cost effective under certain circumstances, as you have just indicated. On the other hand, we are only now understanding the environment in which those machines work well enough to be able to design specific airfoils that are applicable to those kinds of conditions. So that's an area in which joint work between industry and our Government laboratory can move that technology rapidly, and where I would think in 5 to 10 years we may get it to the point where it is relatively cost competitive for bulk electricity. It's not that now except in special circumstances. But those special circumstances are significant, as you have already indicated.

In general, if you talk about commercialization in the sense it's usually been talked about, and its penetration of bulks, power markets, and they're really providing quads and quads of energy—a symptom that I tend to call quadrophobia because I think it's overemphasized.

The situation has changed a lot from the 1970's and I think we need to recognize that. The emerging renewable energy technology simply will not compete in bulk markets today, and they won't compete large-scale for probably one to two decades. Now, if oil prices were today what we thought they were going to be back in 1970, that statement would not be true, but that's not where oil prices are. The marketplace has just changed drastically; oil supplies exceed demand; costs are only about half to a third of what we anticipated them to be; gas supplies are more plentiful; coal technology's improving; and the utility market has changed a lot.

You know, there is actually an over-capacity in many areas, and we don't see a large-scale need for electricity generating capacity in this country in the next 10 to 15 years except in certain special-

ized areas. I think that means that when we look at commercialization, we say, "Well, we can now take advantage from a technological point of view of a period in which we can settle back and systematically develop these technologies." We will have to develop more stringent economic goals, and that then presupposes that there has to be stable funding. And as these things emerge—which will be over a considerable period of time—then they should be moved on into demonstration projects.

So there is something to be said for current circumstances. And generally the intent of your bill is quite reinforcing of what we propose to do. While I think industry will have to recognize that there's substantial economic areas right now to measure penetrations in the market, that will be rather difficult to overcome, and they shouldn't be tilted at in a premature kind of fashion.

I'd like to end now with a quotation from Phil Abelson. Phil Abelson is the long-time editor of *Science* magazine. And I referred earlier to that symposium of the National Academy of the National Academy of Engineering on the energy agenda for the 1990's—what did we agree on?—that electricity will become more and more important, although there is not a real need for major extension capacity in the near term, that when you look at the imponderabilities of what happens in the Gulf; what's the condition of the greenhouse effect; how is the public going to react to their concerns about nuclear, and so on, it's very difficult to say what the specifics will be.

So we're saying the future's indeterminant; you are going to have to go to incrementalism and you're going to have to use a diversity of supplies; and you're going to have to be flexible in the strategies with which you deal with demand; and energy efficiency has to be emphasized.

Having said all that, Dr. Abelson came up with a quotation in one of his editorials that says it better than I could and probably from a more reputable source, I suspect——

Mrs. LLOYD. I don't know about that.

Dr. HUBBARD. Anyway, what he said is, "The overwhelming odds are that the U.S. will eventually be forced to make the transition to an economy based on its own natural resources and employing more efficient use of energy. Either the transition will be conducted in a gradual and orderly manner or it will be conducted in a drawn-out, painful way after a major crisis. Technology cannot come riding over the hill to produce a sudden solution." And I think that is a very accurate statement.

What do we need to do if we're going to have energy superiority? We need to understand our natural resources, and solar is the biggest natural resource we have.

We need to have the know-how. We need to have the knowledge on which we can base the technology. And that's the major role for SERI and it's the major role for the DOE program.

But in addition to that, we have to have an established capability. We have to have an industry that is capable of using that technology and familiar with it.

And so I think the objectives of your bill are quite consistent with that. I do have some concerns about how demonstration projects would be interpreted, and I have some concerns about jus-

tifying a certain number within a certain time, because one has to look very, very carefully in timing. But I applaud you and your Committee for your interest in the subject; I appreciate your support, and thank you for letting me be here today.

[The prepared statement of Dr. Hubbard follows:]

Testimony of Dr. H.M. Hubbard

Director
Solar Energy Research Institute

Before the
U.S. House of Representatives
Committee on Science, Space and Technology
Subcommittee on Energy Research and Development

June 30, 1988

Abstract

In this testimony I address the significant progress made during the first decade of major government-sponsored research in renewable energy technologies, the impacts of multi-year funding, cost-shared joint ventures between government and industry and the entry of renewable energy technologies into the marketplace. Specifically, my testimony will show that:

- The last decade has seen great progress in renewable energy technologies. Renewable energy systems have become more reliable, more efficient, and longer lived. The cost of energy produced by these technologies has decreased by an order of magnitude or more. Markets for specialized applications have emerged and will continue to grow. These applications will provide substantial markets for renewable technologies while the continued research is accomplished which is needed before the renewable technologies will be able to enter the bulk energy markets.
- The impacts of stable, multi-year funding upon research planning and performance would be beneficial to the Renewable Energy Program.
- Cost-shared joint ventures between government and industry, and in the right circumstances demonstration projects, are helpful for bringing technologies from the prototype phase into the commercial phase, for demonstrating the feasibility of systems, and for providing hands-on experience. But, the kinds of joint ventures that would do most good are those that would add to our knowledge base, scientific and technological, take the research from proof-of-concept phase into the more applied and practical phases, and that would help manufacturers overcome basic stumbling blocks on their way to commercialization.
- Both the federal government and the private sector must continue to invest in research and development in the renewable technologies for them to be able to penetrate the bulk power markets and to achieve their large potentials. Significant markets are now emerging in stand-alone, off-grid applications, mostly in overseas markets. These will provide significant export opportunities for U. S. manufacturers. However, because of changes in both world and domestic energy markets and the ongoing restructuring of the domestic electricity industry, more research will be required before the renewable technologies can significantly penetrate the U.S. electricity markets.

What Progress Has Been Made in Renewable Energy Technologies in the Past Ten Years?

"[In the past decade], renewable energy systems have become increasingly reliable, more efficient, and longer lived."

We have made great strides. Renewable energy systems have become increasingly reliable, more efficient, and longer lived. The cost of energy derived from most of these technologies has decreased by an order of magnitude or more. These advances have resulted in emerging markets for most of the technologies. Where ten years ago there were virtually no markets in the emerging renewable technologies, today, even though the renewable energy industries are fledgling, the present markets are significant and their potential substantial, especially for distributive uses and stand-alone applications. The international markets alone, where distributive systems are finding their first and widest application, are already worth hundreds of millions of dollars per year and are growing.

These markets have grown primarily because of the scientific and technological advances we have made in the renewable energies. Compared with where we were ten years ago, our theoretical understanding of the basic conversion phenomena, the solar resource, and the pertinent materials sciences is much advanced. Our scientific and technical data base is more extensive, and we have a better understanding of the factors limiting the technologies.

These general comments, however, give a hazy picture of the progress. It would be more instructive if I presented some of the advances made in the specific renewable technologies of photovoltaics, wind energy, buildings research, and biofuels.

"Eleven years after the start of the [National Photovoltaics] program, the United States has installed tens of thousands of photovoltaic systems around the world."

Photovoltaics. Before the inception of the DOE's National Photovoltaics Program, photovoltaic systems were used almost exclusively to power satellites. Now, eleven years after the start of the program, the United States has installed tens of thousands of photovoltaic systems around the world. They include large systems, like a 6.5 megawatt installation in California; small systems that pump water in Nigeria or light a cabin in the Montana mountains; and intermediate-size systems, like Alabama Power's 100 kilowatt amorphous silicon installation. Take the Coast Guard's example of the increasing utility of photovoltaics. It currently has more than 10,000 photovoltaic systems to run its buoys and remote communications. Moreover, the Coast Guard is seeking additional funds for 6000 more systems because no other current alternative is as inexpensive and dependable in remote applications.

Since photovoltaics were used exclusively in space, the cost of photovoltaically generated electricity has dropped by more than 100 fold. In fact, in just the last decade, the cost has dropped from more than $7 per kilowatt-hour to less than 35¢ per kilowatt-hour. In the same span, the lifetime of terrestrial photovoltaic modules has gone from less than five years to the point where most companies now offer ten-year warranties. Recent progress in the program portends that the new generation of crystalline silicon modules will last more than 20 years.

Researchers have devised methods to inexpensively purify silicon. They have also discovered semiconductor materials and have designed new material combinations for use in photovoltaic devices. They have, for example, brought two

especially promising thin-film materials to maturity: amorphous silicon and copper-indium-diselenide. The potential market for thin-film materials is enormous.

Flat-plate crystalline silicon modules are reaching beyond 15% efficiency. And some production cells are reaching efficiencies of 18% to 20%. And, some experimental cells have gone beyond 22% efficiency under normal sunlight and have approached 28% efficiency under concentrated sunlight. These efficiencies are greater than was thought possible just a few years ago.

But researchers are not resting on their laurels. They are designing multijunction cells that could eventually enable photovoltaic devices to reach conversion efficiencies as high as 35% to 40%. They are also trying to combine low cost, reliability, and durability with high efficiencies.

"Since the mid-1970s . . . improvements in the cost, performance, and lifetime of wind machines have reduced the cost of wind-generated electricity more than tenfold. . . ."

Wind Energy. Since the mid-1970s this country has made large strides in wind technology. Improvements in the cost, performance, and lifetime of wind machines have reduced the cost of wind-generated electricity more than tenfold, from more than $1.50 per kilowatt-hour to between 8¢ and 12¢ per kilowatt-hour. The reduction in cost and the improved reliability are big reasons for the dramatic rise in wind-generated electricity in the United States. Although wind energy conversion systems are eminently useful for dispersed applications, the United States employs them mostly in wind farms, where they supply supplemental power for utilities. California is the pioneer in this field, with about 1500 megawatts of installed capacity.

The improvements in cost, performance, and lifetime of wind machines are related to advances the DOE's research program has made in the technology. We have, for example, improved our understanding of wind shear — the variation in wind speed with height above ground. And, by operating and testing experimental and commercial wind machines, we understand better the vibrational characteristics of wind turbines and the loads induced by gravity, centrifugal forces, and average wind conditions. We have also improved components and subsystems such as (1) advanced teetered rotors, which reduce the loads induced by wind sheer; (2) more flexible towers and drive trains, which weigh and cost less; (3) improved gearboxes; and (4) improved fabrication techniques for steel, wood, and fiberglass blades.

Researchers have developed a new family of airfoils that satisfy the unique requirements of fixed-pitch, horizontal-axis wind turbines. These designs avoid the undesirable performance characteristics of aircraft airfoils used in early wind turbines. And, in resource assessment we are beginning to understand the micro-environment — the effects that natural and man-made objects have on local wind patterns.

Researchers have also investigated the environmental effects of wind turbine operation, particularly noise and radio or television interference. This research has provided the basis for the industry-wide consensus on noise measurement techniques currently being developed by the American Wind Energy Association.

Buildings Research. In this technology, we try to help natural processes through materials research, lighting research, and innovative designs that will help us heat or cool our buildings. Perhaps the best way to understand the progress of the last decade is to review a few examples.

"Two new concepts devised for space heating and cooling are the electrochromic window and the vacuum window."

In materials, one innovative concept is *phase-change materials*. These materials change their state from solid to liquid as they absorb heat during the day, and then by reversing phase change, release their stored heat at night when it is cooler. This has an obvious function for space heating. Researchers improved this phase-change idea by making materials that change from one solid state to another at room temperature (solid-to-solid), absorbing and releasing thermal energy as they do so. With more development, these materials could be incorporated into common building materials, such as particle board and gypsum wallboard, to produce lightweight building components with high thermal storage capacities.

Two new concepts devised for space heating and cooling are the electrochromic window and the vacuum window. *Electrochromic windows* have a thin coating whose optical transmission can be changed by electrical means, thus controlling the amount of solar energy passing through the window. *Vacuum windows* use a high-vacuum space between two glazings with low-emittance coatings to achieve an insulating value nearly equivalent to that of a solid wall. The two glazings are separated by small glass beads and their edges laser-welded in a vacuum chamber.

Researchers have improved on ways to cool and heat houses using solar energy. One concept is the use of *desiccant materials*, such as lithium chloride and silica gel, to absorb water out of the air and exhaust the water outside the building. This is especially useful for space cooling in humid climates. But the use of known materials is just one of the possibilities in this field. Researchers have also discovered several new organic materials with high moisture absorptivity that look as promising as desiccant materials for solar cooling.

For water and space heating, researchers have also designed more efficient heat pumps and flat-plate solar collectors. Both of these concepts are currently enjoying some commercial success.

Researchers have created techniques that allow architects to design buildings so that they may make better use of natural daylight, conveying it into the interior of buildings. These efforts in lighting research can save large amounts of energy that would otherwise be used for lighting and cooling office buildings.

"Researchers . . . developed a methanol fuel system for cars that catalytically dissociates liquid methanol into hydrogen and carbon monoxide."

Biofuels. This is a vast area of research where we are finding ways to derive energy from wood, herbaceous crops, or agricultural and municipal wastes. Although the energy from biomass can be produced in all forms, our research has concentrated on liquid and gaseous fuels. *Liquid fuels* include alcohol fuels, diesel and gasoline derived from wood and waste (biocrude), and diesel and gasoline derived from microalgae and plant oils. *Gaseous fuels* include biogas, synthetic gas (syngas), and hydrogen.

We can make *alcohol fuels* from trees, grasses, and common agricultural crops such as corn and other grains. In the last ten years, researchers have advanced the technology for making or using alcohol fuels in several ways. They have, for example, developed a methanol fuel system for cars that catalytically dissociates liquid methanol into hydrogen and carbon monoxide. These gases are then burned at high efficiency in a modified piston engine. The process produces a high thermal conversion efficiency and reduced exhaust pollutants. Researchers have also identified enzymes that break cellulose into more easily fermentable units. This will increase the yield of alcohol fuels. Research is also under way in acidic processes and the development of new microbes to efficiently change xylose, the

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"We have cultured and developed about 20 microalgae strains that . . . produce up to 66% of their body weight as oil."

major hemicellulose sugar in hardwoods, into xylulose, a more readily fermentable sugar.

In the past decade, researchers have also explored producing gasoline and diesel fuels from wood, plants, and municipal wastes. Their promising avenues of research include fast pyrolysis and catalytic, high-pressure pyrolysis.

We have also developed ways to produce diesel and gasoline from *microalgae and oil seeds*. We have cultured and developed about 20 microalgae strains that prolifically produce oil. Some of these strains produce up to 66% of their body weight as oil.

We are also studying the use of anaerobic digestion to produce *biogas*, medium-Btu and high-Btu methane gas from animal, plant, wood, and municipal waste. Anaerobic digestion is the degradation of organic matter by bacteria, in the absence of oxygen, to produce biogas. To optimize anaerobic digestion, we are developing different strains of bacteria, engineering better strains of herbaceous crops, and developing reactor systems.

Thermal gasification is a well-known technology for converting plant or waste material into synthetic gas (*syngas*). And today, there are many commercial uses for syngas. But these gasifier systems produce only low-Btu gas that generally contains too much nitrogen. Program researchers are developing ways to produce high-quality, medium- and high-Btu synthetic gas. They are improving reactor designs and gasification techniques.

One successful SERI gasifier design is a high-pressure oxygen gasifier based on principles derived from downdraft gasifiers used during World War II to power vehicles. In this design, over 99.95% of the tars and oils in wood or agricultural waste feedstocks are converted to synthetic gas. The gas can then be converted to methanol or ammonia for fuel use. This project received an IR-100 Award, and has been taken over by private industry for scale up and commercialization.

"[Solar thermal] systems can be used for many things, including process heat, electrical generation, the manufacturing of chemicals, and the destruction of hazardous wastes."

Solar Thermal. Solar thermal systems convert sunlight to useful energy forms by concentrating the sun's radiation to produce high temperatures. The systems then convert this energy into process heat, electricity, or products such as chemicals. A little over a decade ago, this field was untouched. Since then, the technology has progressed rapidly. Three main types of concentrators have evolved. *Parabolic troughs*, which provide for low concentration, focus the sun onto a tube of fluid to produce temperatures up to 750°F. The low-grade heat is used as process heat or to generate electricity. *Parabolic dishes* focus the sun onto a receiver mounted above the dish. Achieving temperatures as high as 5400°F, dish systems can be used for many things, including process heat, electrical generation, the manufacturing of chemicals, and the destruction of hazardous wastes. *Central receiver systems* use many heliostats (highly reflective mirrors) to track the sun and reflect its rays to a central receiver atop a tower. Although this concept was developed primarily for electrical applications, the high temperatures these systems can attain (up to 4500°F) make them useful for non-electrical applications as well.

In a decade of research and development, we have improved solar thermal systems on all fronts, developing better concentrators with higher ratios of concentration, longer-lasting and cheaper reflective materials, and a variety of receiver and reactor systems. For example, SERI researchers have developed low-cost, high-

ly reflective, lightweight stretched-membrane heliostats that can be used in either parabolic dish collectors or in central-receiver systems.

We have demonstrated the viability of the first generation of the solar thermal technology and have identified where we can make further improvements. Because they are modular, solar thermal systems can generate electricity economically at power levels from tens of kilowatts up to hundreds of megawatts. Modularity offers the additional advantages of short construction times and incremental investments.

These advantages are part of the reason that over 140 megawatts of solar thermal electric generating capacity has been installed in Southern California. This capacity, which is privately financed, could grow to over 500 megawatts in the next several years.

Besides process heat and electrical generation, solar thermal systems can be used for many other applications. Because of the high concentrations they achieve and the unique characteristics of the solar flux, solar thermal systems can be used for destroying hazardous wastes, making chemicals, liquefying coal, and processing space-age metals and ceramics.

These more sophisticated applications, however, require higher concentration ratios and more advanced receiver, reactor, and conversion technologies. Researchers are working on these concepts and have already shown that they can reach concentrations of up to 65,000 suns. Such achievements bode well for the future of solar thermal systems.

"... in photoconversion we have begun to understand the basic processes fundamental to all life — processes that are involved in changing photon energy into other energy forms."

Other Technologies. This, of course, is just a brief review of the things accomplished in the renewable energy technologies during the past ten years. There are many other technologies to consider. In *ocean thermal energy conversion*, for example, we designed an open-cycle system that not only will produce electricity but will supply fresh water for drinking and aquaculture. Through ongoing research in *resource assessment*, we understand the solar resource much better, have substantially increased our resource data base, have designed sophisticated resource models, and have developed instrumentation for accurately recording and analyzing the solar resource. And in *photoconversion* we have begun to understand the basic processes fundamental to all life — processes that are involved in changing photon energy into other energy forms.

What Benefits Might We Expect From Stable and Consistent Funding over a Three to Five Year Period?

"... stable, consistent, multi-year funding would be a boon for renewable energy research, and an important step in bringing renewable energy toward its potential."

We feel that stable, consistent, multi-year funding would be a boon for renewable energy research, and an important step in bringing renewable energy toward its potential.

In the past, our national research program on renewable energy has suffered from instability. In the early years, we were trying to conduct research in a crisis atmosphere where the pace was hectic, the influx of funds was climbing geometrically, and the demands for demonstrable results were immediate and overwhelming. That kind of atmosphere made it difficult to plan and conduct intelligent, long-range research, which is what the renewable energy technologies required. Some programs were, in fact, poorly planned and executed.

The drastic funding reduction that occurred in 1981-1982, was no better, however, because it also forced changes too rapidly. It did not allow us to properly phase down programs. Consequently, we lost some valuable assets, people, and time, and were again unable to appropriately plan and conduct research.

Notwithstanding the continued decline in the total solar budget over the last five or six years, until recently SERI was able to maintain stability by assuming an increasingly larger role in the DOE's renewable energy research program. This enabled us to build and maintain our excellent research staff, build a mature, competent management team, and make SERI into a research institute that has gained respect among its peers across the nation and around the world. Nevertheless, we, and the entire solar program, are back under the cloud of uncertain funding. This has made it increasingly difficult for us to retain all of our valued personnel or to attract other high-quality professionals. We have also had to eliminate some programs and reduce others.

Stable, consistent, multi-year funding would help us to better plan our research. We could reemphasize some programs and revitalize others. We could retain top-quality researchers and professionals and attract others. Staff morale would climb. We could continue to build SERI into the world's leading center for renewable energy research. Research would accelerate and results would come forth in a more timely manner.

We understand that much of this may sound too general. So it may be more instructive to point out how stable and consistent funding could help us in just one of our research disciplines — biofuels.

Biofuels is a broad research area with great promise and a wide set of technologies. Through the biofuels technologies we will be able to derive heat, electricity, chemicals, pharmaceuticals, liquid fuels for transportation, food, lightweight plastics, and more. Unfortunately, because of funding problems, we cannot explore all of the promising avenues.

Adequate, stable, consistent funding would help. It would, for example, better help us to develop the enzymes, microbes, and bacteria we need to produce liquid and gaseous fuels from wood, herbaceous crops, and agricultural and municipal wastes. It would help us accelerate other work, such as developing bet-

"Through the biofuels technologies we will be able to derive heat, electricity, chemicals, pharmaceuticals, liquid fuels for transportation, food, lightweight plastics, and more."

ter methods of fermentation, genetically engineering new organism strains, discovering new and better ways to cultivate energy crops, enhancing anaerobic digestion, and designing reactor systems for gasification.

We could equally accelerate our programs in biofuels conservation technologies where, for example, we are investigating ways to make lightweight, inexpensive plastics from biomass. One especially important use for such lightweight materials is in automobiles. Another use, which comes from our ability to make biodegradeable plastics, is in polystyrene packaging for fast-food chains. Developing these plastics not only would help our nation conserve energy but would enable us to more wisely utilize our biomass feedstock.

There are many other especially fertile areas of research that stable and consistent funding would enhance. For example, we could investigate ways to synthetically produce or enhance photosynthetic processes — an avenue of research that Nobel Laureate Sir George Porter believes may answer much of our energy and food needs in the future. Or, we could increase our program on using biotechnology to make adhesives for the plywood industry.

These examples give you an idea about what we could do in biofuels. What we could do in biofuels with stable and consistent funding, however, we could do equally as well in our other technologies — photovoltaics, wind energy, solar thermal, buildings research, ocean thermal energy conversion, resource assessment, etc.

Should Cost-Shared Joint Ventures Be Encouraged?

"The kinds of joint ventures . . . [that] would do most good are those that would add to our knowledge base, . . . take the research from proof-of-concept phase into the more applied and practical phases, and . . . help manufacturers overcome basic stumbling blocks . . ."

Yes, I believe that cost-shared industry and government joint ventures should be encouraged. But only where appropriate. Whether or not it is appropriate will depend entirely upon the kinds of joint ventures we are talking about. Demonstration projects, for example, can serve as a transition from the prototype phase to the commercial phase. They can help demonstrate the feasibility of systems for commercial use. They can convince the public and interested parties of the utility of the systems. And they can provide hands-on experience and valuable operation, maintenance, and resource information. To accomplish all this, they must be carefully considered and diligently planned. But, most important, they must be appropriately timed. There is a stage in the development of any technology where we should look at the operation and maintenance of the system and show the utilitarian feasibility of the technology. What concerns me about this bill is that it calls for a specific number of demonstration projects involving renewable energy technologies that could place us in a position where we may force a technology to demonstration before it is ready and thus do more harm than good.

I support the idea of cost-shared projects and believe that encouraging cost-shared ventures with industry is very important. The kinds of joint ventures that I think would do most good are those that would add to our knowledge base — scientific and technological — take the research from proof-of-concept phase into the more applied and practical phases, and that would help manufacturers overcome basic stumbling blocks on their way toward commercialization. These are the kinds of joint ventures where government managers and researchers would form partnerships directly with the industries that would commercialize the product. We presently have several such joint ventures. Three examples follow.

". . . the market potential for thin films is diverse and immense."

Amorphous silicon. Amorphous silicon and other such thin-film materials just may be the photovoltaic technologies of the future. Thin films use very little material, can be deposited over large areas, and can be adapted to mass-production techniques — all of which decrease the cost. Amorphous silicon, in fact, has already carved itself a burgeoning market in small consumer products such as hand calculators and watches. But the market potential for amorphous silicon is much larger and more diverse than this. It not only has great potential for ever widening applications in photovoltaics, but also for xerography, thin-film transistors for flat-panel displays, image sensors and integrated drive circuits for printers, and much more.

The market potential for thin films is diverse and immense. And much is at stake here: world leadership in this technology and its markets.

To meet its potential, however, amorphous silicon technology must progress. We must make the modules larger, more efficient, and more stable (i.e., keep the module efficiency from deteriorating). We must also understand the large-area deposition process; develop alloy materials that will help us reach higher efficiencies; explore multijunction concepts, where we layer single-junction cells on top of each other to capture more of the sun and make the devices even more efficient; and devise alternate deposition methods that can produce thin films at higher throughput and yields.

SERI and the National Photovoltaic Program are doing all this through the Amorphous Silicon Research Project, in which we conduct cost-shared programs with U.S. industry and fundamental research studies at universities and research laboratories, including in-house research at SERI. In our first three-year initiative (1984-1987), cost-shared 30% by industry, we accomplished several things, including new, faster deposition techniques, and an 8%-efficient, one-square-foot module; this should soon translate into enhanced markets. Our second three-year initiative (1987-1990) is a $40 million program that is 50% cost-shared by industry. Our objectives are to achieve stable, 10%-efficient single-junction and 13%-efficient multijunction modules, and find ways in which to make larger, more efficient panels, faster and cheaper.

To reach our objectives, we must have the continued commitment of the government to these cost-shared ventures, as well as the support of the fundamental research programs that focus on the more basic questions involving photovoltaic materials and phenomena, physical and deposition processes, modeling, and measurement.

"... SERI scientists, conceived of a new reactor that would turn biomass, such as agricultural residues or wood chips, into high-quality, synthetic gas."

Biomass Gasification to Liquid and Gaseous Fuels. In the early 1980s, SERI scientists conceived of a new reactor that would turn biomass, such as agricultural residues or wood chips, into high-quality, synthetic gas. The gas could be used to make methanol or other alcohol fuels or combusted to generate electricity or to provide process heat. Its advantage over similar gasifiers lies not only in its use of renewable resources but in its innovative design, which allows it to convert these feedstocks into gas more cheaply, efficiently, and cleanly, particularly for small sizes.

In cooperation with the Colorado School of Mines and Hazen Research, Inc. in Golden, Colorado, SERI researchers developed the gasifier and proved the concept. In 1982, Industrial Research Magazine recognized the concept as one of the 100 most important research accomplishments of 1982.

In 1983, DOE transferred patent rights to M. Grabowski, the co-inventor of the gasifier. He became founder and vice president of SynGas, which scaled up the gasifier for the primary use of generating electricity. SynGas has since invested six million dollars in development and now, after technical collaboration with SERI, has built and operated a gasifier to process 15 tons of biomass per day. Recently SynGas merged with Cogeneration Capital Associates, forming Tamal Energy, Inc. (TEI). Under this new partnership, Tamal Energy, Inc. plans to build gasifiers that process 50 tons of biomass per day. At this size, each gasifier would have a generating capacity of 2.5 million watts, enough electricity to power more than 1200 homes. Next year, TEI plans to use these new gasifiers to install a 10-megawatt plant for the Northeast, which is sufficient to provide electricity to almost 5000 residences.

In a parallel development, Olathe Manufacturing, Inc., which manufactures wood chipping and turf equipment, adapted the concept in 1982 primarily for the purpose of using renewable resources to generate industrial process heat. Over the intervening years, Olathe and its founder have invested $3 million to develop gasifiers that can produce as much as 4.5 million Btus per hour, enough energy to supply all the heat and electricity to 125 homes. Olathe has cost-shared the development of the gasifier with the State of Kansas. Olathe plans to have commercial systems available sometime in 1988 or 1989.

"SERI researchers . . . [are] developing a unique vortex reactor that . . . [can] . . . produce crude oil for use as a boiler fuel and . . . produce olefins which [can] be converted into gasoline."

Pyrolysis of Biomass. Pyrolysis is a process in which biomass is rapidly heated in the absence of oxygen and the complex molecules in biomass materials or wastes are broken down. In this process, which is very similar to cracking in the petroleum industry, useful products, such as crude oil, can be drawn off at various points in the reaction process. SERI scientists recognized the potentials of this method and started investigating different products. Starting with liquid and gaseous fuels, the research expanded to include adhesives and other valuable by-products.

Liquid and Gaseous Fuels. Early in the 1980s, SERI researchers started developing a unique vortex reactor that allowed the biomass cracking process to proceed with a rapid transfer of heat and short reaction times. The primary intention of this process was to produce crude oil for use as a boiler fuel and to produce olefins which could be converted into gasoline. In 1986, these engineers and scientists studied the basic principles involved and combined the pyrolysis process with catalytic conversion to produce aromatic gasoline, a blending stock used by petroleum companies to make high octane gas.

The private sector became very interested in these concepts. Currently, Pyrotech (Kansas) is scaling up the vortex reactor for the purpose of generating boiler fuels. Pyrotech, with SERI providing technical expertise under a collaborative agreement, is building units that will be able to process 35 tons of biomass per day. They will install their first units at the Samoa (CA) site of Louisiana Pacific, a forest products company dedicated to becoming energy sufficient at all of its 128 plants.

"Mobil Oil Corporation is interested in [SERI's] catalytic process to produce aromatic gasoline."

Mobil Oil Corporation is interested in the catalytic process to produce aromatic gasoline. Aromatics, used as octane enhancers, are vaulable and scarce and will become increasingly so as we phase lead out of our gasoline.

Unfortunately, since the research on aromatics is less than two years old, we have not yet reached the point where it is economically competitive with the conventional petroleum process. The critical step in achieving this is to scale-up the reactor and test it. Our researchers are following an innovative path for doing this. The question they asked is: why just work on scale-up? Why not, rather, have your scale-up efforts pay off by resulting in useful products that are a natural outcome of the scale-up process? In answer, they decided to test the reactor by investigating an application that was in perfect accord with the scale-up: adhesives from the pyrolysis of biomass. These adhesives, they recognized, could become economically competitive in a relatively short time frame, thus sweetening the transition toward the economic reduction of aromatics.

". . . scientists . . . are . . . investigating ways to use the vortex reactor to pyrolyze waste sawdust or bark into phenolic resins."

Adhesives. SERI scientists, and the team of experts they assembled from academia and industry are, under the sponsorship of the Office of Industrial Programs of DOE, investigating ways to use the vortex reactor to pyrolyze waste sawdust or bark into phenolic resins. These resins, which currently are derived from petroleum, are used by the forest products industry as adhesives for wood paneling, plywood, molding, other board products, and insulation. In 1987 the U.S. produced about 2.6 billion pounds of these resins at an average cost of 50¢ per pound.

After only 18 months of investigation, the research team has developed formulations of pyrolysis oils that could replace 50% of the phenol in molding compounds and plywood adhesives. Moreover, they project that the cost of the phenol de-

"... scientists ... are ... investigating ways to use the vortex reactor to pyrolyze waste sawdust or bark into phenolic resins."

rived from sawdust or bark could be as little as 10¢ to 16¢ a pound, or even less. Replacing 50% of the petroleum-derived phenols could save our nation almost a tenth of a quad (which is equivalent to 17 million barrels of oil) of energy per year by 2010 and, in plywood and molding products alone, could initially save the forest industry $30 million dollars annually in feedstock costs. All of this with a relatively small R&D investment from the government.

It is potential like this that has attracted a host of interested companies, many of whom have been directly involved since the beginning of this program either through research or through an industrial review board. Interested private sector parties include the American Plywood Association, Boise Cascade, Borden Adhesives, Gaylord Chemicals, Georgia Pacific, Koppers Co., Perkins Industries, E. Seidel and Associates, and Weyerhaeuser Co.

Renewable Energy Technologies and "The Marketplace"

"... which renewable technologies are closest to commercialization ... ?"

My invitation to testify asked me to, "give us your opinion of which renewable technologies are closest to commercialization and what needs to be done to bring them to the marketplace in a reasonable timeframe." The question was well phrased because if one asked twenty people that same question one would likely receive twenty different answers. I will address my answer to what I prefer to call "the emerging" renewable technologies. It is clear that there are renewable technologies that presently contribute significant amounts of energy to our national needs — hydroelectric, the direct combustion of wood, and perhaps geothermal energy. Passive building designs and solar hot water heaters are well accepted and there exists for them an established consumer market; but there still remain some unresolved technical issues.

There are fledgling companies that are surviving by manufacturing and selling the emerging renewable technologies — does that make them commercialized? I do not think so. Most present-day applications of renewable technologies are in specialized, high-value, end-use situations or where subsidies make them economic. That is, mostly remote, off-grid applications. For example, the United States Coast Guard has more installed PV systems than anyone in the world, but they are all small systems that have proven to be very cost effective in powering remote warning and communications devices. In fact, most of the experts are predicting that during the near term — at least for the next ten years — the primary market for renewable technologies will be in overseas, export markets.

"Traditionally we have viewed the 'commericialization' of renewable energy technologies as their ability to enter and compete in the utility-scale, bulk energy markets."

The reason for this will become more apparent if we look at domestic electricity markets. Traditionally we have viewed the "commercialization" of renewable energy technologies as their ability to enter and compete in the utility-scale, bulk energy markets. If we are going to continue to use this same definition of commercial success then, we must conclude that none of the emerging renewable energy technologies can successfully compete in today's energy marketplace.

Domestic and world energy markets have changed dramatically since SERI was established. World oil production capacity greatly exceeds demand. Natural gas supplies and reserves are greater than anticipated. Improvements in coal mining and combustion technologies have greatly increased coal-on-coal competition — to the extent that zero real price growth is likely in the near term. The bottom line is that for the next twenty years energy supplies will be more abundant and cheaper than previously thought.

"The traditional situation of a regulated monopoly earning a set return on its capital investments is changing rapidly."

Then one must add to the above the restructuring that is taking place in the electricity markets. The traditional situation of a regulated monopoly earning a set return on its capital investments is changing rapidly. Many utilities overbuilt based upon erroneous growth projections and find themselves with excess capacity. Their experience under PURPA and the willingness of independent power producers to build any new needed generating capacity have changed many utilities' attitudes about being in the power-generation business. Some utilities have already declared, like Virginia Power, that they do not plan to build new generating capacity, but rather to allow independent power producers to bid on any capacity that they might need to add. Some utility experts are projecting

that this will eventually lead to utility companies becoming regulated companies that only distribute power generated by independent producers in a competitive free-market environment.

All of these changes tell us that the "window" for renewable energy technologies to enter the marketplace that we all foresaw with the advent of $30-40 per barrel oil has been closed for the near term. This calls for a new strategic view on energy R&D in general and renewable energy technologies in particular.

"The closing of the window on rapid market entry, opens the window for the continued development of the technologies."

Our view at SERI is that the closing of the window on rapid market entry, opens the window for the continued development of the technologies. We now have the opportunity to continue along the established ten-year curve of improving performance, reducing costs, and extending lifetimes before we will have to deploy and rely upon the renewable technologies. It allows us the opportunity to place greater emphasis on the science that can produce breakthroughs, rather than to focus upon trying to make incremental improvements in the technologies. It allows us to continue making improvements in the face of the constant uncertainties surrounding the energy supply situation that we face as a nation which daily imports almost half of the petroleum that we use.

I would like to be able to offer a more definite answer. But in a constantly changing environment it is unwise. I believe that, given the uncertainties that we face in the energy arena, it is better to continue to develop the broad range of the research paths currently encompassed within the DOE Renewable Energy Program. As in the past, we will discontinue research on those technologies that prove to be "losers" for scientific or technical reasons and convey to the marketplace those that can be cost-competitive. Until then it would seem to be the best policy to continue to support research over a broad range of technologies, which at this time we cannot expect a fledgling industry to support.

Having said all of this, we are all aware that there are noneconomic considerations that often intervene and shape markets. There are many markets that have been influenced by policy decisions at the federal level. One such noneconomic factor is getting a lot of press lately and is staring us in the face — the "Greenhouse Effect." Some very good scientists consider this to be the most important long-term issue facing the world today, with the sole exception of the possibility of nuclear war.

What will happen to the energy markets if our government, or the international community, decides that we must begin very soon to reduce the acceleration of the gas buildup which causes the greenhouse effect? Energy markets would then become heavily skewed in favor of the emerging renewable technologies because they do not create excess carbon dioxide — the major cause of the greenhouse effect.

Of course, we cannot anticipate when such a call will come or in what guise it will appear. But when it does, the renewable technologies will have to answer the call. This is but another argument for the continued long-term support for research in renewable energy technologies. I would like to close with a quote about the need for a long-range energy R & D policy from an editorial in *Science* magazine by Philip H. Abelson, who said:

> *The overwhelming odds are that the United States will eventually be forced to make the transition to an energy economy based*

on its own natural resources and employing more highly efficient use of energy. Either the transition will be conducted in a gradual, orderly manner, or it will be conducted in a long drawn-out painful way after a major crisis. Technology cannot come riding over the hill to produce a sudden solution.

DISCUSSION

Mrs. LLOYD. Thank you a lot, Dr. Hubbard.

Yesterday, I met with both at EEI and we sort of picked up on where you just left off, that we need to go from our base as we look at our energy future. And that the Mideast has half of our oil reserves, a fourth of our gas reserves, and we need to plan our energy policy from basically what we have. Certainly we have an abundance of sunshine. We have a lot of sunshine this year. Maybe more sunshine than we really want this year.

In that perspective, we have been looking at the focus on the greenhouse effect. Of course, we're not—our reactors, we are working from a passive reactor concepts.

Don't you think that the work that certainly you're doing at SERI will not just be factored because of oil prices but going by our mental concerns it will delegate the solar programs to a higher degree?

Dr. HUBBARD. Yeah, I agree with that. And, of course, that's now emerging as a major kind of public concern. And again in the meeting I keep referring to, we said about the greenhouse effect was it may well be the "show-stopper" with respect to fossil fuels.

I think you can be sure there's enough scientific evidence to now to know that the greenhouse effect is real. The rate at which it will come upon us or precisely what the impact will be is very, very difficult to predict. What our people at the National Center for Atmospheric Research are saying is that the change is inevitable. But that what we will have to do is try to manage our energy consumption such and our energy supply such to keep that rate of change something that we can adapt to.

Mrs. LLOYD. We're going to have to do a better job of taking care of this planet, there's no doubt about that.

Dr. HUBBARD. You know, the two technologies are applicable to that, primarily nuclear, of course, and renewables. A high degree of public discomfort about nuclear and some significant questions to be asked. How the public will react to that and what we will be able to do with it in this country is really as much a concern of how the public is going to react and how they're going to perceive that as it is technological, although there are legitimate questions on both sides, I think.

Mrs. LLOYD. We've got a lot of work to do in both areas, not only in nuclear but renewables, and that only——

Dr. HUBBARD. Excuse me.

Mrs. LLOYD. We have a lot of very important research work ahead of us.

Dr. HUBBARD. I mean, as I said before, I see them as essentially complementary resources.

Mrs. LLOYD. And I would agree with you.

Returning to H.R. 4226, beyond the three-year authorization, do you think the solar programs would benefit from this legislation?

Dr. HUBBARD. Yes, again with my caveat relative to demonstrations, which I'd like to see perhaps clarified or modified a little bit.

Mrs. LLOYD. In that light, give me your opinion of how we can avoid forcing demonstrations; what criteria we could use.

Dr. HUBBARD. It's delicate, isn't it, because you want to put enough pressure in there to be sure that something happens but you don't want to put so much pressure on that people get pushed into doing something that——

Mrs. LLOYD. I know, but what are our criteria?

Dr. HUBBARD. I think you have to look to industry for the criteria. I think industry can tell us to first approximation, if they are able to sit down with the people on the technological side so that they have a clear understanding of what the technology can provide. Then I think they can tell us when things need to be commercialized if they can count on the Government to be a substantial partner. So I think the motivation and for pushing for cost-sharing, and specifically asking us in the program to look at that and provide you with proposals makes sense. To link it to a particular year or particular number is somewhat dubious.

Mrs. LLOYD. Last week we had hearings on superconductivity and the subject of venture capital was very much in the forefront of the testimony.

Do you think that we have the venture capital in the renewables to give the private sector the incentives they need?

Dr. HUBBARD. Venture capitalists are going to want a return of, you know, 17 to 20 percent that they can see pretty clearly. And they are going to want to know that their partner is going to be there. It's going to be difficult to attract an awful lot of venture capital in the near term. I think we, for energy applications per se.

You know, we're seeing venture capitalists come to us and look at specialized applications of things that are coming out of solar technology that are of interest, and some of them are kind of odd. In the biofuels program one of the things we spend a lot of time on is the cultivation of the aquatic species. We do that because you can put together aquatic species that produce the equivalent of diesel fuels and those can be processed into liquid fuels—very high cost at the moment. In the process of which we have learned a tremendous amount about the care and the feeding of algae, and the handling of aquatic environments.

So there're venture capitalists in Colorado who came to look at our technology on how would one do these kinds of things, how would one of our people and what is he doing—he's using the discharge from a coal plant, the cooling water, to raise oysters in our higher altitudes of Colorado. Now, it relates to energy in many, many ways but it's a kind of odd sort of a spinoff.

I think if we're going to maintain the technological advantage in this country we have to look for that kind of synergism coming out of Government programs.

Mrs. LLOYD. Thank you very much.

Mr. Morrison?

Mr. MORRISON. Thank you, Madam Chairman.

Dr. Hubbard, I guess I'd like to take the few minutes we have to ask you about the Department of Energy procedure in determining budgets and what they're going to recommend for expenditure in certain areas and how that ties together with the potential for attracting joint ventures, the sort of team play that I think all of us believe may well be one of the best approaches to the steps toward commercialization.

Do you sense that the procedure they're employing is adequate, and do they ask you for very specific things, or do you have some flexibility on making recommendations for what you sense might be the best potential as the next step?

Dr. HUBBARD. We have an opportunity to put our ideas and perceptions in, and admittedly it works better in some programs than in others. In photovoltaics, in particular, where we have a scientific and technical committee set up joint with industry, much of the strategy behind the program emerges out of discussions between us in the field and industry and then it goes to the program managers in Washington who review that. And admittedly they have to review in the light of political reality with respect to resources that they anticipate would be available, and the policy is elucidated to them by the policymakers in Washington.

But we do have an opportunity to put our technical opinions into the program. And through us, and in some areas at least, we are able to consult with industry quite effectively. It isn't totally uniform.

Mr. MORRISON. Do you believe there's appropriate consideration given to maybe extra investment in an area that needs a little hand-holding and as opposed to, say, in a technology that's fairly close to commercialization, or close enough, at least, that private enterprise will join you in the effort?

Dr. HUBBARD. No, it gets into that difficult area of how you perceive the Government role, and what the Government role should be.

You know, we have an opportunity to advocate particular ideas, or point out particular areas that we believe could benefit from additional funds, or at least additional attention.

We can't really make the judgments as to how the resources ought to be allocated because we're not privy to the other pressures that are on the people in Washington that have to make up the overall budget.

There has been a traditional polarization between the Government and industry, and research and development areas that relate to consumer use and relate to privatization.

We have not in the past, just as a matter of principle—matter of practice, really—had adequate discussion between industry and the people who make up Federal programs; and industry has probably not had adequate influence. Now, that's a general statement.

I think I could say at this point, though, that in the area of renewable energy and conservation, they've probably made more progress in breaking down that cultural barrier than in most of the areas of the Government. That's not to say it's where it needs to be yet. I think we have to basically structure a different working relationship between those two major components of our R&D establishment.

If we don't do that—and it has been done in West Germany and in Japan to a greater degree—then we're going to be at a disadvantage.

Mr. MORRISON. Well, somehow I wish that this Subcommittee, with all the hours we spend looking at some of these things, could somehow be a greater factor in measuring the ones that we think have tremendous potential for private investment and some others

that are obviously farther away and need a strong push from the dollars that we have.

One of our frustrations—and I'm sure yours—is sometimes even DOE takes your ideas and they get shot down in OMB or somewhere else in the bureaucracy.

Dr. HUBBARD. There are a lot of hoops to get through, and we can't always tell sometimes where the hurdles are; some of them are technological, and some of them are ideological,

Mr. MORRISON. That's true.

Well, thank you. We are inspired by your work.

Dr. HUBBARD. Thank you.

Mrs. LLOYD. Thank you, Mr. Morrison.

Mr. Hefley?

Mr. HEFLEY. Yes, thank you, Madam Chairman.

Dr. Hubbard, as I understand what you testified regarding electrical generation, the technology is getting there; the economics of it are not there because of the whole world energy picture right now. Is that what you were saying?

Dr. HUBBARD. For bulk electricity I think that's correct, at least in this country. The average cost of electric power generation in this country, or average price, is somewhere around, oh, between 5 and 6 cents, maybe more like 5 cents.

Photovoltaic technology at the moment—if you put it into place—is about 35 cents per kilowatt hour. Wind systems are the order of between 9 and 12. And the solar thermal systems are roughly that same range, maybe 10 to 15. You get arguments about these numbers, and it's hard to give a totally unequivocal answer, but that's approximately of where we are.

Now if you're talking about peak-power generation, you know, you can afford to spend more money for that because that addresses the immediate need. And if you can meet peak-power generation, then you may not have to make expensive investment in basic power systems.

So you can afford to spend more; you can afford to spend more per unit of generating capacity for systems that can be brought on line in a hurry and that can be brought on line in small increments than you can if it's going to come in big packages with long-lead times. And, of course, renewable fits that description. So renewables can afford to be somewhat higher priced but it can't be clear out of the ball park. And it's beginning to approach the region that it has to be in, and in most of those technologies we can project roughly when we're going to get there.

But we still believe that the window of a major investment and major increase and major need for electrical; generating capacity in this country is probably the order of a decade to two decades off; and the principal competition is solar in that area, or natural gas-fired turbines. That immediately raises the question of what about carbonacious fuels and how serious is the greenhouse effect, because consuming natural gas, of course, continues to contribute to carbon dioxide. Burning certain kinds of renewable fuels from biomass would also, but when you grow the wood you're taking the carbon dioxide back out, so you get pretty close to a steady-state system.

Mr. HEFLEY. So what you're saying is that whereas we may not need it to the extent some people thought we would right now, eventually we're going to—be it a decade or two decades—and we had better be ready, and that's part of what you're doing.

Dr. HUBBARD. Well, furthermore, that's right. And there are substantial markets already, as Mrs. Lloyd has pointed out. And if we do not work with industry to maintain the viable industry that addresses those markets, then we're going to find out that when we do have a large-scale domestic need for electric-power generation, it's going to be supplied from abroad. And as I think said to this Committee before, then we're put in the position of both of importing oil and importing alternative energy technologies, and I don't think we want to be in that position.

Mr. HEFLEY. Don't want to be in both, for sure.

What about the solar thermal systems as they relate to the hazardous waste problems? Would you speak to that? I understand that they are——

Dr. HUBBARD. We have been——

Mr. HEFLEY [continuing]. A great potential application there.

Dr. HUBBARD. We have been looking at other applications for concentrated sunlight other than generation of electrical power. And one of the things that both we and Sandia Laboratory are working on—we're working on it in conjunction—is the destruction of toxic waste.

We have evidence in the laboratory that this is feasible and that it may have advantages over current systems. So we believe that deserves a concerted look, and it is one of the elements that we are currently bringing into the solar thermal program.

Dr. HEFLEY. How far are we from some answers in that as to whether or not that is feasible?

Dr. HUBBARD. Well, if you have to talk about feasibility—in the first place is it scientifically feasible; will basic science permit you to do it. We know enough about that to say, yes.

Well, then you have to say, "Well, is it going to be practically or engineeringly feasible?" We don't know enough about that yet to be able to say whether that is true or not. And it's hard to say how long that would be. It might be the order of five years or so. And then once you get that far, then you have to say, well, all right, but can that be engineered or designed in such a way as to be economically feasible. So we're just beyond the scientific feasibility kind of a benchmark.

Mr. HEFLEY. Thank you very much, Dr. Hubbard.

Mrs. LLOYD. Thank you very much.

Mr. Fawell?

Mr. FAWELL. Thank you, Madam Chairman.

You had mentioned that in regard to demonstration projects that one would look to industry for guidance in regard to commercialization. And that ties in, I think, with the measuring rod one usually hears in reference to cost effectiveness.

I'm wondering if cost effectiveness is considering the greenhouse effect that we're all talking about now, is going to be, or should be, necessarily the measuring rod.

You also indicated that this is involving Government policy. It seems to me that when one recognizes that of all the various

energy sources, as I recall—what little I know about hydrogen as an energy source—I guess we are—the Government is flying some planes on hydrogen. There is to say that there are certain instances where cost effectiveness goes out the window and the need is such that we will elect a different fuel.

And I'm just wondering if—you talk about, well, we've got two decades here in which under the circumstances in terms of cost effectiveness that we can wait—we hope we'll have consistent long-term funding.

I'm wondering if you've got that much time. And in terms of policy for the demonstration projects or whatever that you reconsider as Government policy the question as to whether industry is going to tell us how fast we ought to be going.

Dr. HUBBARD. Industry's answers are going to be primarily dictated by their perception of the marketplace and their perception of the fairly immediate marketplace, because they want a return on a pretty short-term basis. They will occasionally invest, you know, if they're prosperous anyway, and if you have a sound—I worked for duPont for a long time and duPont would invest in some areas not expecting any return for years because they could afford to do it and because they thought the long-term investment would be there. But you don't build a pilot plant or a commercialization project on that basis. You only do that when you're reasonably sure that the economic return will be there if the plant performs as you expect it to. And that's generally what the industry means when you talk about a demonstration project.

There are certain kinds of things, of course, that the market doesn't value. And because it really doesn't know how to do that, and many of the things that relate to environmental protection and to health standards and so on are in that category.

A greenhouse effect is real all right. It is not going to be catastrophic. That is that you suddenly wake up some morning and find out that the temperature went up five degrees and New York City's under water. You know it won't happen like that. One would anticipate—I've seen estimates as to what will happen at sea level, you know, and it—they're saying anywhere from, oh, maybe 18 inches to 5 feet by the year 2100, maybe, something like that—and that's based on modeling that's kind of improbable. So there is a fair amount of time to deal with the greenhouse effect .

On the other hand, there is absolute—there's huge—huge inertia in our system that takes a long, long time to change an energy system. So I'm not saying we ought to wait. I'm saying that we need to go ahead and develop the technologies to the point that we know they are at least engineeringly feasible.

I think it is very often too soon, though, to try to demonstrate something that approaches economic feasibility. And when you put in incentives that make economic return based on something other than technological performance—as happened, for example, with some of the early wind systems, then you make trouble—we make trouble for ourselves long term.

But, yes, you can't rely on industry to evaluate anything. They can tell you when it's time to demonstrate the technology—to prove that you can get an economic return in the next 5 to 10 years. But they can't tell you when you need to address a subject

because there is a major problem at the marketplace, and I'm concerned with——

Mr. FAWELL. Nor do they. I think at times really measure——

Dr. HUBBARD. No, what happens in those cases, of course, is that the Government then has to—if anything is to be done in the way of producing long-term equipment or investing in research, the Government basically has to fund that one way or another, the Government can fund it by creating market. But unless it's a sustained market, you'll create a temporary demand and then that drops off and then the industry's in trouble again.

Mr. FAWELL. Well, my point is, of course, that if in measuring cost effectiveness and fossil fuels to meet that test—but if one looked at all the deaths from black lung disease and respiratory ailments, and from what we're hearing now of all the various gases that go into the atmosphere and many ill effects—and that what we're doing today won't show up maybe for a decade or so, but it's irreversible, perhaps—it takes a hundred years to scrub those gases out of the atmosphere, and so forth.

When one adds just the health effects and the hospital costs, et cetera, it may well be even if went to business' standards that there are some new alternative fuels which are maybe a couple of years away only in terms of cost effectiveness—the society as a whole. And that, I guess, is where we come into play. We're the ones who's supposed to set Government policy and we may say that just as rightly so, Defense may say, we're not concerned about cost effectiveness and having hydrogen as a fuel or for our defense, we may also be approaching that point where we're not going to measure cost effectiveness in the old way—we're paying too much. And especially in terms of we're doing irreversible damage to the space and earth and maybe we had better sound the signal as the oil shortage tout us to action in regard to solar energy. You mentioned solar——

Dr. HUBBARD. I would agree. I would say don't—if you don't want us to do that sort of thing, then it has to be on a sustained basis. Otherwise, industry can be brought—you know, can be "motivated" to invest to establish something. And then the Government policy changes and the government withdraws from the arena and then industry is hanging out there.

Mr. FAWELL. Absolutely, and I would agree 100 percent.

Dr. HUBBARD. And that's a major problem. In the jargon of the trade, you know, there are a lot of external costs that are not normally valued in the marketplace because they're not incorporated into the internal costing. And that's where relying on the market process to tell you what to do can well fall down.

Mr. FAWELL. Thank you very much.

Mrs. LLOYD. Dr. Hubbard, thank you so much for being with us. We always enjoy having you testify before the Committee.

Dr. HUBBARD. My pleasure.

Mrs. LLOYD. Wish you a good year.

Dr. HUBBARD. Come out and see.

Mrs. LLOYD. We'll be there, we do hope.

Our next witness is Dr. Peter Blair. We're awfully glad to see you also. Dr. Blair's Program Manager of the Energy and Minerals Division at the Office of Technology Assessment.

We do look forward to your testimony. Peter, you may summarize as you wish and your entire statement will be made a part of the record. Please proceed.

STATEMENT OF DR. PETER D. BLAIR, PROGRAM MANAGER, ENERGY AND MATERIALS, OFFICE OF TECHNOLOGY ASSESSMENT, U.S CONGRESS, WASHINGTON, DC

Dr. BLAIR. Thank you, Madam Chairman.

Thank you for the opportunity to share with your Subcommittee some of the findings of OTA's past as well as some ongoing work as it relates to the R&D needs and commercial prospects of conservation and renewable energy.

I fear if I go through my testimony, even outline it, I may repeat some of Dr. Hubbard's remarks, so I'll try not to do that. And instead, I'll extract from it some of the key points that I tried to make regarding the current commercial viability of conservation and renewables in perhaps a somewhat broader context—and indeed, I'll try to make four points.

One, I call the sort of multiple motivations point that we now are in with respect to whether or not and at what level we should be supporting these technologies.

The second is a kind of new decision environment in which we find ourselves for making energy investments in industry and elsewhere.

The third point is a kind of what I call the "Chicken Little" point, which is the kind of eroding industry infrastructure of the conservation and renewables industry and what might be necessary to salvage that.

And finally, perhaps a few points about the changing underlying economic landscape that's sort of changing the environment within which we perceive the role of conservation and renewables.

With respect to the multiple motivations—yesterday, as several of you pointed out here this morning, that two of your sister subcommittees convened a joint hearing on the subject of technologies for remediating global warming, and we discussed that a bit this morning. But in that hearing, I believe, underscored really only one of the host of reasons why perhaps it's time—or the time seems especially appropriate for a sustained increase in our really very modest efforts to mine this considerable resource of energy efficiency in perhaps all sectors of the economy, as well as to preserve our ability to develop renewable resources.

Indeed, that motivation—a motivation for such actions is—arises not only from the increase over global warming—or the concern over global warming—but a range of other concerns which perhaps collectively comprise a very compelling rationale for such actions. These include, of course, the near-term environmental impacts of burning fossil fuels, such as the acid rain problem and urban air pollution.

But the added concerns, and perhaps the more frequently cited ones that I hear perhaps in the energy circles is the increasing level of oil imports and its negative impact on the trade balance. It now comprises a third of our negative trade balance. Our national security interests in the inevitable concentration of future world oil

production and reserves in the Middle East. You mentioned in your opening statement that roughly 60 percent of our reserves are sitting in the Middle East. And finally, the need for industrial innovation to restore U.S. competitiveness in world markets.

All of these concerns are addressed with accelerated commercial development of new energy supply and conservation technologies. And I believe that any one of these concerns perhaps won't be sufficient to dramatically elevate our interest in conservation renewables, but collectively they may comprise a very powerful motivation.

Let me quickly address energy conservation. In retrospect, over the last decade and a half, the efforts to improve energy efficiency have been perhaps the most successful components of U.S. energy policy. In many cases, investments in energy efficiency have exceeded even our most optimistic forecasts; even the folks that are pushing the technologies, contributing to perhaps the happy outcome of no increase in total energy-consumption since 1974, despite a 35 percent accumulative growth in GNP.

More than a decade later since these efforts were initiated, we are still seeing the results of these energy-efficiency investments. And really, I think to illustrate how far we've come, Dr. Hubbard mentioned the National Academy meeting several weeks ago—or about a month ago, I suppose—that dedicated the new West Coast facility, the Beckman Center. And the keynote speech at that meeting was given by Robert Malpus, who's the managing director of British Petroleum. And Mr. Malpus' entire speech to an audience of energy experts was a plea and, indeed, a plan for placing energy efficiency at the core of energy policy in the 1990's. And at least as far as I can recall 10 years ago, hearing such a speech from an oil company executive would have been a rather remarkable experience.

Yet, I believe it's increasingly becoming simply part of our culture, and the technical potential provided by R&D to date is really far from being realized. And, indeed, in the written testimony I show several figures illustrating historical trends in energy efficiency and the technical potential for homes, appliances, motor vehicles, and others. So it's really the gap between the technical potential and the commercial availability that is the real market, I think, for RD&D dollars at this point.

The second point I mentioned was the new decision environment for energy investments. And despite this remarkable period of progress in R&D efforts to advance our technical potential, the public policy initiatives aimed at accelerating the rate of penetration of these technologies have really been only marginally successful, I think. Over the last decade, while there was usually sufficient incentive to replace capital stock with more efficient technology in a life-cycle-cost basis, the initial capital cost was often enough of a disincentive to defer the investments until the existing capital stock was depreciated—when you think about replacing your refrigerator and it breaks down.

So this, along with the complacency about the accompanying low and stable energy prices, puts somewhat different demands on our research and development efforts; in particular, I believe energy efficiency, as well as renewable energy applications and the opportu-

nities for them, are now frequently being viewed as collateral benefits to other investments, such as those as improving competitiveness in U.S. products in world markets, or improved environmental control. And that, indeed, may be the key to Dr. Hubbard's venture capital problem, to initiate improved process controls in industry as an energy efficiency investment if it's billed as a way to reduce labor costs—which it often is considered—higher in priority in corporate board rooms, it will, by the way, improve energy efficiency rather dramatically. So these collateral benefits, I believe an important marketing perspective for energy efficiency investments in today's sort of lackluster environment about energy investments.

The third point I wanted to raise was the "Chicken Little" point—that is, about the eroding industry infrastructure. In general, the oil price trends over the last several years, coupled with the declining Federal as well as private support of RD&D and the changes in the tax treatment of renewable energy and conservation investments have severely diminished this sense of urgency about renewable energy as well as energy efficiency and, hence, the rate of technical progress in the near term commercial development prospects.

So the eroding industry infrastructure for both research and commercial development, that we hear very often in the authorization hearings, continues that eroding reports about it; both a number of firms and their financial viability continues to decline.

Indeed, in many cases right now only—on the commercial side, only those companies holding already-negotiated standard offer number 4 agreements with California utilities, or perhaps the wherewithal to acquire those agreements from those who hold them, are likely to have real development prospects over the next several years.

The current strategy for developing both conservation and renewable technologies assumes really that there's adequate time to let private development efforts fill the energy supply gaps as they appear. And this strategy may not be sufficiently sensitive to the concerns that really originally prompted interest in those technologies. And I believe the Federal Government plays the principal role in encouraging and sponsoring the timely technology development for reasons such as national economic and security interests or environmental benefit.

And finally, the last major point I want to make is the underlying economic landscape and how it's changed our energy decision environment.

Several weeks ago, OTA released its assessment entitled "Technology and the American Economic Transition Choices for the Future" that addressed really fundamental structural changes that have occurred in the U.S. economy over the last decade. And this change in economic landscape has had a profound impact on the relative effectiveness of different energy policy tools. Indeed, the very specific or technologies specific initiatives of the 1970's, such as the geothermal loan guarantees, or the conservation tax credits, in some sense seem somewhat anachronistic when compared with the general economic incentives that promote economic competitiveness in world markets that collaterally promote energy efficiency and oil alternative technology.

I guess finally, Madam Chairman, in your request for me to appear, you asked me to address demonstrations specifically. In our study of several years ago on new electric power technologies, we identified many key aspects of successful demonstration programs and I recounted those in my written statement and I believe they were discussed pretty well by Dr. Hubbard in several of the questions that came up.

So I'd be pleased to answer any questions.

[The prepared statement of Dr. Blair follows:]

TESTIMONY OF DR. PETER D. BLAIR
PROGRAM MANAGER, ENERGY AND MATERIALS
OFFICE OF TECHNOLOGY ASSESSMENT

before

Subcommittee on Energy Research and Development
House Committee on Science, Space and Technology

Conservation and Renewable Energy
Research and Development

June 30, 1988

Madame Chairman:

Thank you for the opportunity to share with your subcommittee some of the findings of OTA's past and on-going work as it relates to the research and development needs and commercial prospects of conservation and renewable energy technology. As you may be aware, OTA has completed a number of major assessments on the subject, some of which were requested by this Committee. These include New Electric Power Technologies: Problems and Prospects for the 1990's, Industrial Energy Use, Energy From Biological Processes, Energy Efficiency in Buildings, and others. Currently, OTA is engaged in an assessment entitled Technological Risks and Opportunities for Future U.S. energy Supply and Demand that addresses this issue among many others in the context of long term energy policy. In my testimony today I address the status of research and development for both energy conservation and renewable technologies, the role of these technologies and their commercial availability in broader U.S. energy policy, my general perception of how the Department of Energy's Fiscal Year 1989 research and

development budget request for renewable energy and energy conservation programs is responsive to that role, and finally, to the extent I am able at this time, the features of H.R. 4226. Several weeks ago I addressed this subject for the Senate Energy and Natural Resources Committee and I refer you to my testimony of May 18 for some of my additional thoughts.

THE CASE FOR ENERGY EFFICIENCY

First let me address energy conservation. In retrospect, over the last decade and a half, efforts to improve energy efficiency have been the most successful components of U.S. energy policy. In many cases, investments in energy efficiency exceeded even the most optimistic forecasts, contributing substantially to the happy outcome of no increase in total energy consumption since 1974 despite a 35 percent growth in GNP. For the most part, these investments occurred in industry, transportation, commercial buildings, and residences when fuel was a very significant operating cost, and at the same time, when the payback for such an investment could be realized quickly. In short, many actions taken were easy marks. While some of these actions were changes in patterns of energy use, such as lowering thermostats, most were investments in technology, either retrofits, such as insulating existing homes, or new investments, such as energy efficient new construction or autos with improved mileage. Indeed, more than a decade later we are still seeing the results of such investments as they continue to accumulate. While there was usually sufficient incentive to replace capital stock with more efficient

technology on a life cycle cost basis, the initial capital cost was often enough of a disincentive to defer the investment until the existing capital stock was depreciated. The public policy incentives designed to accelerate this shift to a more energy-efficient economy have been only marginally successful. Nonetheless, the trend toward increased energy efficiency continues, even in the current period of low and stable prices relative to the mid 1970's, perhaps being carried in part by the inertia of the pattern of energy efficiency investments initiated in the 1970's. However, since the rate of penetration of energy efficiency improvements has been slow, albeit steady relative to its technical potential, that technical potential is far from being realized, even with current technology. Figures 1,2, and 3 illustrate the recent historical trends in energy efficiency and technical potential for homes, appliances, and motor vehicles.

While the momentum of improving energy efficiency continues in the 1980's, the investment decision environment within which such investments are made has changed substantially from that of the 1970's. In contrast to the trends in the 1970's, the energy efficiency gains and opportunities in the 1980's, which in many cases have been just as significant as those in the 1970's, are frequently being viewed as only collateral benefits to other investments, i.e., those aimed at improving competitiveness of U.S. products in world markets. Moreover, the technology for energy efficiency continues to advance, so the opportunities for improvements in energy efficiency continue to expand in virtually all sectors of the economy. However, capitalizing on these opportunities at an accelerated rate, if

such a strategy is judged to be optimal from a national perspective, may require policy intervention (e.g., research, performance, standards, and incentives).

Capitalizing on energy efficiency improvements viewed as a collateral benefit of other investments provides a somewhat different policy focus than the more traditional policy motivation of explicitly focussing on reducing energy imports, although the result is the same. However, the policy instruments are different. In an environment of low and stable energy prices, the motivation to innovate comes from the pressure to be competitive and hence to turn over capital more quickly in order to maintain highly productive industry. The turnover is usually not directly related to the energy efficiency improvement possible with new capital investments, but is often a natural byproduct. Hence, the kinds of energy efficiency improvements most likely to be adopted are those that provide other benefits as well. For example, improved process controls in industry might be adopted in order to reduce labor costs, but could have dramatic energy saving benefits as well.

The dependence of the U.S. economy on foreign energy sources remains the Nation's most critical long term energy problem. The ability we developed over the past decade to deal with sort-term disruptions (via the Strategic Petroleum Reserve), increased oil production form non-OPEC sources, and dual fuel capabilities in industry will not affect the long-term trend toward dramatically increased U.S. imports of oil which are

expected by many analysts to be above 60 percent in the 1990's. Moreover, while energy efficiency improvements have been remarkably successful, the current rate of capital turnover incorporating these improvements is not sufficient to affect appreciably our rapidly increasing dependence on imported oil. The current period of stability in energy supply and prices, while a welcome reprieve, cannot be used as a justification for complacency about the future. Indeed, this period provides the opportunity to advance the technical potential for energy efficiency improvements as well as develop and demonstrate technology for timely adoption.

THE ROLE OF RENEWABLE ENERGY TECHNOLOGIES[1]

Increased use of renewable resources continues to be an important component of our Nation's long term strategy to ensure continuity in energy supply at reasonable cost. Like energy efficiency, the promise of contributing to improved national security and reduced economic vulnerability by providing a diverse and virtually inexhaustible energy supply is the principal benefit of renewables. In addition, some renewables provide smaller scale design features that can be better matched to energy demand and are less dependent on uncertain forecasts. Finally,

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[1]For purposes of this discussion we define renewable technologies as those that do no use conventional fossil or nuclear fuels, e.g., biomass, hydropower, passive solar, solar thermal, photovoltaics, wind turbines, and geothermal. (While geothermal energy strictly speaking is not a renewable energy resource, we include in in this discussion since it has many renewable resource features and, for purposes of energy research and development, is considered part of the renewable energy technology protfolio.)

some renewables provide considerable environmental benefits. Indeed, yesterday in a joint hearing of two of your sister subcommittees, I made many of the same points I will make today regarding the commercial viability of renewables, but in that hearing I posed them primarily in the context of their potential role in reducing CO_2 emissions.

Some renewable technologies are already quite mature, such as hydropower, some biomass technologies, solar collectors, and passive solar design features. Others are considered to be much longer range options such as ocean thermal energy conversion, wave and tidal generators, solar power satellites, and others. Increased use of the mature commercial technologies is limited by low cost of conventional fossil fuels or availability of resources, e.g., solar heating and hydropower, respectively. Some renewable technologies, such as photovoltaics, geothermal and wind, have commercially available designs but these designs do not currently compete well with traditional technologies, with some exceptions. Moreover, as we gain experience with some renewables, we learn more about their own adverse environmental impacts, e.g., hydropower and wind. The exceptions are mostly where the technologies are deployed in the most favorable resource locations such as geothermal power in The Geysers, California or wind turbines in the Altamont Pass near San Francisco. Many of these technologies, however, have the potential for considerable improvement in cost and performance. Finally, other renewable technologies such as solar thermal power and some advanced biomass technologies (including biomass-based synthetic liquid and gaseous fuels) have very few

commercial applications, but also have great potential for improved cost and performance. Many of these issues are being analyzed in OTA's ongoing assessment on the future of U.S. energy supply and demand cited earlier.

The technologies in the latter two categories (those with some commercial applications and those that are "near-commercial," waiting for escalations in fossil fuel prices and continued technical development) could be in a position for significant commercial application in the 1990's, but not at their current rate of technical development. For most renewables, the goal of research, development, and demonstration remains to reduce costs and increase performance so that these technologies can compete with more traditional energy sources. Performance improvements, cost reduction, and resolution of uncertainties will all occur, but the rate at which these improvements occur will depend on sustained progress in research, development, and demonstration, and survival of an industry infrastructure.

Table 1 summarizes the current status of selected renewable technologies along with several other alternative generating technologies and the industry that supports them. The table is a kind of summary of the testimony I provided last year in these hearings. In general, the last several years of low and relatively stable energy prices, coupled with declining federal and private support for research, development, and demonstration, and changes in the tax treatment of renewable energy and conservation investments has severely diminished the sense of urgency about

energy efficiency and renewable energy, and hence the rate of technical progress and near term commercial development prospects. The eroding industry infrastructure for both research and commercial development that I reported on last year in these hearings continues. Both the number of firms and their financial viability continues to decline. In many cases only those companies holding already negotiated Standard Offer Number 4 agreements with California utilities (or the wherewithal to acquire those agreements from those who hold them) are likely to have development prospects over the next several years.

Nonetheless, technical progress still appears to be proceeding, at least for some technologies. In particular, photovoltaics continue to be sustained by interim markets of specialized remote applications and consumer electronics. Prospects for more extensive applications in remote areas appears likely as well, which has provided the incentive for major industry sponsors, such as ARCO Solar, Solarex, and Chronar, to stay active and to continue impressive progress toward lower cost. Similarly, the success of small binary geothermal power units, on the heels of mature commercial development of vapor dominated resources at The Geysers, have kept some spirits alive for geothermal industry (e.g., in Hawaii). Other renewable technologies, however, have not fared as well. For example, the lack of interim or subsidized markets has brought solar thermal and wind technical as well as commercial development to a virtual standstill.

In the authorization hearings last year I noted that current low oil prices have brought privately financed research, development and demonstration of biomass synthetic fuels to a virtual standstill. There has been renewed interest in several biomass technologies in the last year, however, but not so much for reasons of energy supply. Instead, urban solid waste disposal problems have prompted renewed interest in municipal solid waste power plants, although the availability of effective separation and emission control technologies is still an important concern. Similarly, local air quality concerns have provided the stimulus for renewed interest in alternative transportation fuels in some urban non-attainment areas, although the continued low cost of conventional fuels and the likely competition from coal-based synfuels remain as serious obstacles for biomass-based alternatives. Nonetheless, automobiles and trucks still comprise 65 percent of U.S. oil consumption, so promoting a diversity of alternative fuels for oil replacement remains very important.

CURRENT RESEARCH AND DEVELOPMENT POLICY CONTEXT

The current U.S. strategy for developing both conservation and renewable technologies assumes that there is adequate time to let private development efforts fill energy supply gaps as they appear. This strategy, however, may not be sufficiently sensitive to the concerns that originally prompted interest in these technologies. In particular, private industry cannot be expected to explicitly include environmental concerns or considerations of foreign policy and national security prominently in

corporate investment decisions. The Federal government plays the principal role in encouraging and sponsoring technology development for such reasons. Of particular concern is assuring availability of liquid fuels as substitutes for oil or improved efficiency in the use of oil, on which virtually our entire transportation system relies. Another concern is finding more environmentally acceptable ways to generate electricity. The current period of low and stable world oil prices, relative to the 1970's, has provided a window of opportunity for developing supply substitutes and more efficient end use technologies, to ensure commercial availability of these technologies in the 1990's.

In the early 1980's the policy tools thought most appropriate for accelerating commercial availability of alternative technologies were most often direct energy policy initiatives, such as technology-specific tax incentives, loan guaranty programs, etc. The appropriate policy initiatives may no longer necessarily be explicit energy policy initiatives alone, since, as noted earlier, the decision calculus for investing in alternative technology and energy efficiency has changed. Perhaps viewing energy alternatives and improved energy efficiency as a collateral benefit has really been the case all along and policy makers weren't sufficiently sensitive to it. Nonetheless, such a perspective ultimately affects the focus of research and development as well, since the kinds of technologies most likely to thrive in such an environment are in many cases different form those most attractive in an environment of urgency about energy. Indeed, decision makers can afford to be more discriminating and demand

higher standards of new equipment, thus requiring even more emphasis on commercial demonstration of new technologies.

Several weeks ago OTA released its assessment entitled Technology and the American Economic Transition: Choices for the Future that addresses the fundamental structural changes that have occurred in the U.S. economy over the last decade. The changing economic landscape has had a profound impact on the relative effectiveness of energy policy tools. For example, the technology-specific initiative of the 1970's, such as the geothermal loan guarantees or the conservation tax credits, seem strangely anachronistic when compared with more general economic incentives promoting economic competitiveness in world markets that collaterally promote energy efficiency or alternative technology.

FEDERAL ROLE IN RESEARCH, DEVELOPMENT AND DEMONSTRATION

Last year in the DOE budget authorization hearings I recounted OTA's findings from several past assessments regarding the federal role in conservation and renewable energy technology development. I would like to reiterate those findings. Perhaps among the most important conditions necessary to sustain conservation and renewable energy technology development in the United States is a continued Federal presence in research, development, and demonstration (RD&D). While many of these technologies are no longer in the basic research phase, development hurdles are still formidable and the importance of RD&D remains high.

A critical milestone in commercial acceptance of these technologies is completion of a successful demonstration program. While there is considerable debate in the energy industry over what constitutes an adequate demonstration, two basic categories are often distinguished. One is a proof-of-concept phase which provides the basic operational data for commercial designs as well as test facilities designed to prove the viability of the technology under non-laboratory conditions and to reduce cost and performance uncertainties. The other involves multiple applications of a more or less mature technology designed to stimulate commercial adoption of the technology. Generally, activities in the first category are necessary for demonstrating commercial viability and activities in the second category are necessary for accelerating commercial development. Both are necessary for significant commercial adoption.

The length of the appropriate demonstration period will vary considerably by technology. However, the nature of the demonstration program--who is participating, who is responsible for managing it, and the applicability of the program to a wide variety of operating circumstances--is of equal importance.

Generally, OTA has found that successful demonstration programs have the following characteristics:

- o The private sector should have considerable influence in the selection of technologies for demonstration as well as principal responsibility for demonstration program design and management of the demonstration project itself.

- o Private sector proprietary rights and ownership should be preserved, provided that such protection does not inhibit timely development of the technology.

- o Cost sharing between government and industry has generally proved successful in ensuring both careful selection of the most competitive projects and timely completion of the projects.

- o Federal government commitments to a demonstration program should be stable and predictable, i.e., once made, such commitments should be honored for a sufficient period in order to convince developers that government is a "reliable partner."

- o First-of-a-kind, full scale demonstration facilities should include support by all partners involved in the demonstration for not only plant engineering and construction but also for extended plant operations.

CONCLUSIONS

It seems to be an appropriate time to redouble our currently modest efforts to mine the considerable resource of energy efficiency still possible in virtually all sectors of the economy as well as preserve the ability to develop renewable resources. The window of opportunity of low and stable world oil prices masks any sense of urgency, despite a once again rapidly growing reliance on foreign oil. The rationale for policy intervention favoring efficiency derives not only from concern over the level of oil imports per se, but also the national security concern over where future world oil production is concentrated, i.e., the Middle East, increasing concern over the environmental impact of burning fossil fuels, and the need to innovate in industry to be more competitive in world markets. All of these realities collectively serve to elevate the importance of policy initiatives aimed at further improving U.S. energy efficiency in spite of the current period of apparent stability. Important among these policy initiatives is continued attention to the RD&D agenda for energy efficiency. Even a broad policy approach aimed at improving U.S. economic efficiency will require continuing technical improvements in energy efficiency as one of its components.

Renewable energy technologies also remain important elements of the Nation's long term energy supply strategy. Maintaining the potential for increased contribution to U.S. energy supply and even maintaining a viable industry infrastructure for these technologies will require sustained

research and development support. Increased contribution of these technologies in the 1990's will require accelerated research, development, and particularly, demonstration.

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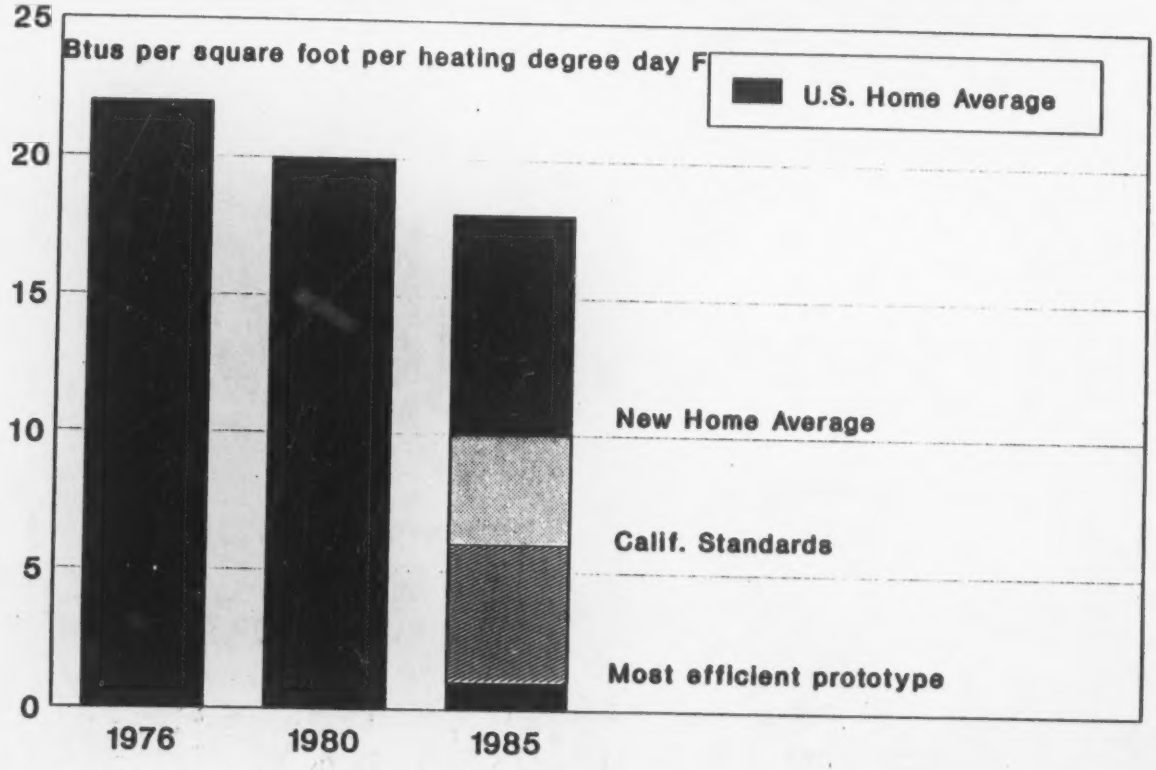
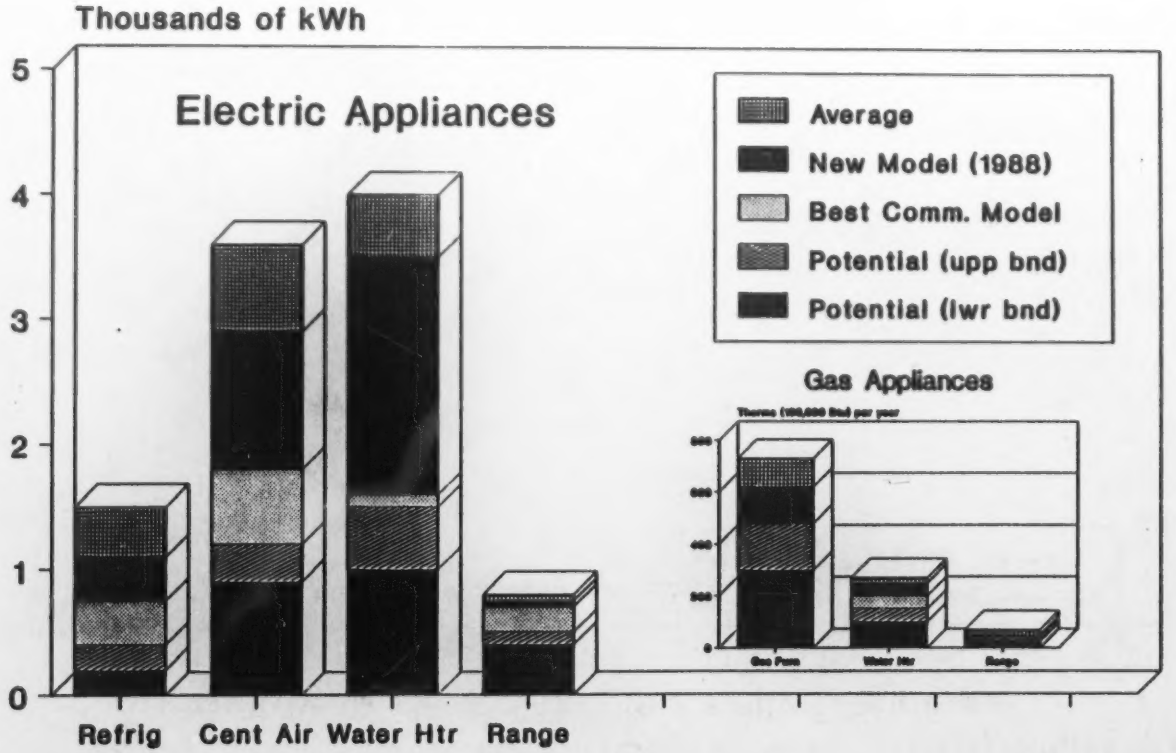
U.S. Residential Energy Consumption

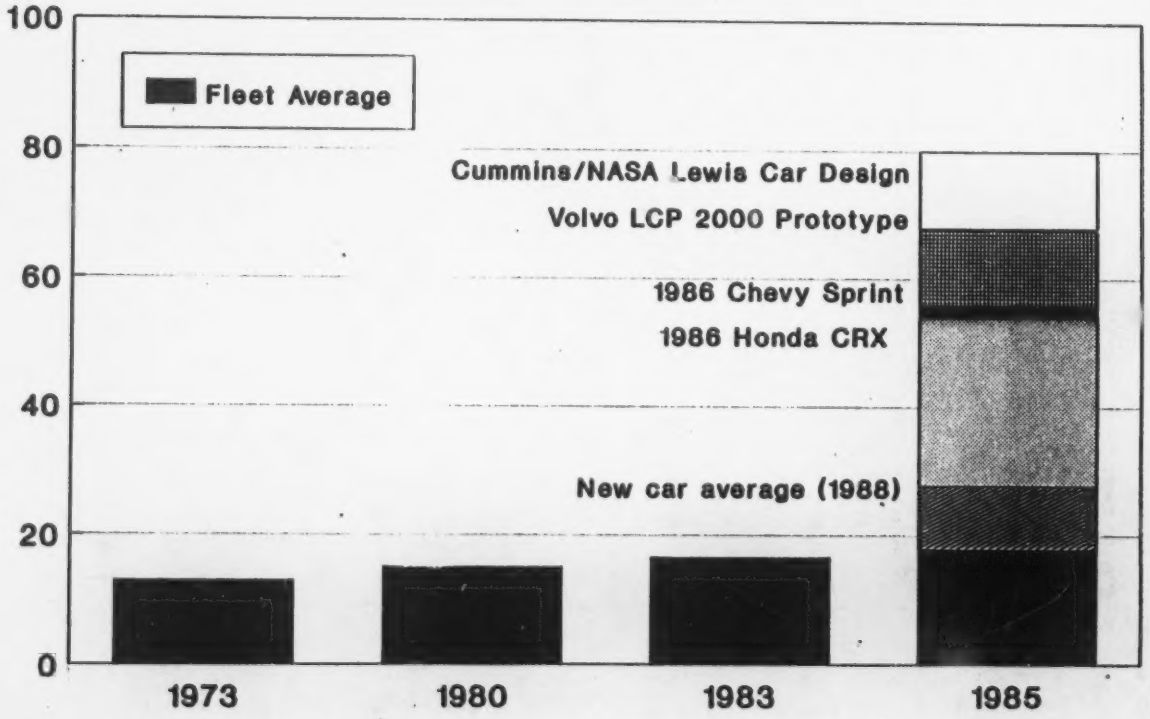
Energy to Heat a Single Family Residence



U.S. Residential Appliances
Energy Efficiency Potential



U.S. Automobile Mileage
(miles per gallon)



U.S. Industrial Energy Consumption
The Role of Energy Efficiency

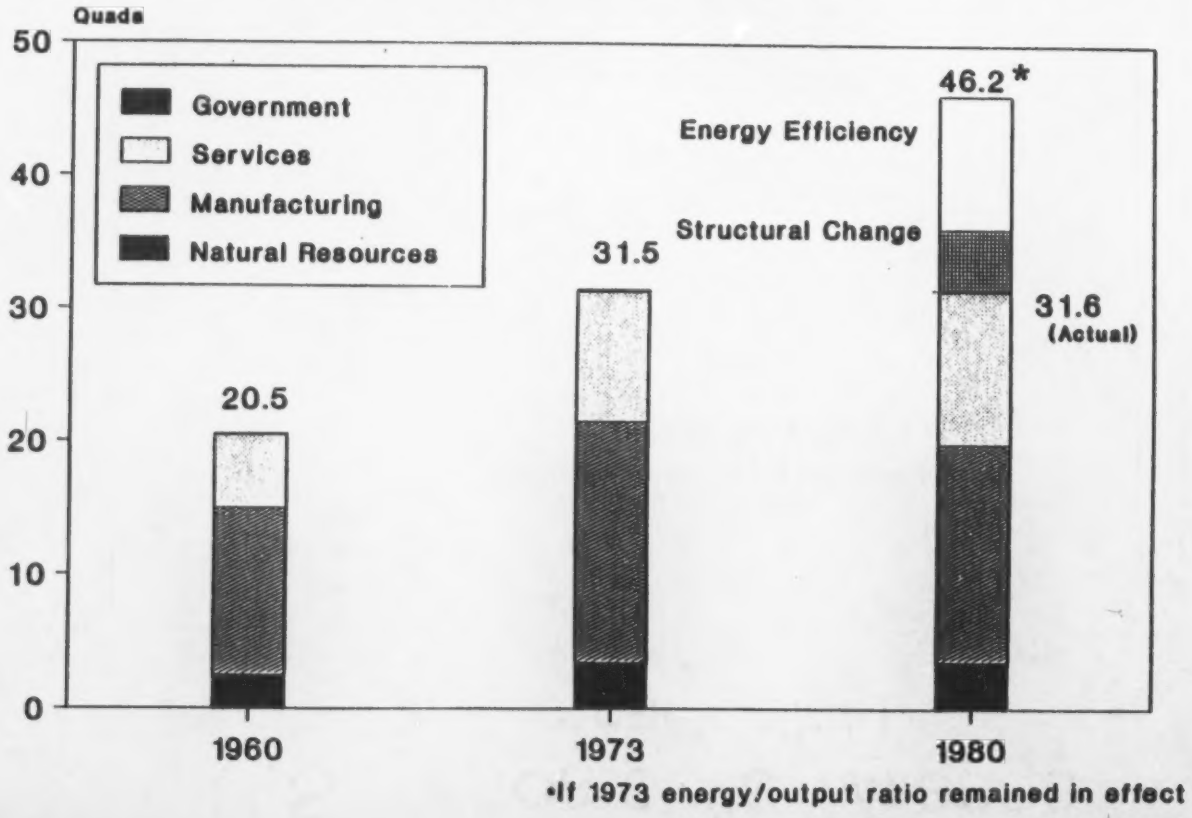


Table 1.—Cross-Technology Comparison: OTA Reference Systems

Technology characteristics	Geothermal	Wind power	Photovoltaics	Solar parabolic dish[1]	AFBC	IGCC	Fuel cells	CAES	Battery storage
General:									
Geographic location	Western U.S.	Entire U.S.	Entire U.S., South better	SW & SE	Entire U.S.	Entire U.S.	Entire U.S.	Entire U.S.	Entire U.S.
Plant size[2]	Small-medium	Small	Small	Small	Large	Large	Small	Medium-large	Small
Development status	Demo-commercial	Commercial	Demo-commercial	Demo	Commercial under construction	Demo	Demo planned	No Demo	Pilot
Lead time[3]	Short-medium	Short	Medium	Medium	Long	Long	Medium	Medium-long	Medium
Siting flexibility[4]	Low	Medium	High	Medium	Medium	Medium	High	Medium	High
Intermittent?[5]	No	Yes	Yes	Yes	No	No	No	No	No
Cost:									
Cost[6]	Medium	Medium	High	High	Low	Low	High	Medium	Low
Profitable?[7]	No	Yes	No	No	Yes	N/A	No	No	N/A
Resource requirements and environmental impacts:[8]									
Primary fuel source	Geothermal brine	Wind	Solar insolation	Solar insolation	Coal/solid fuels	Coal/natural gas	Natural gas	Base load electricity plus natural gas or oil	Base load electricity
Fuel availability	Limited	Limited number of quality sites	Region specific	Region specific	Not constrained	Not constrained	Not constrained	Not constrained	Not constrained
Noise	Medium	Medium to high	Low	Low	Medium	Medium	Low	Medium	Low
Solid waste[9]	Medium	Low	Low	Low	Medium to high	Medium to high	Low	Low	Low
Air quality	Medium to high	Low	Low	Low	Medium to high	Medium to high	Low	Medium	Low
Water quality[9]	Medium	Low to medium[10]	Low	Low	Medium	Medium	Low	Low	Low
Water consumption:[9]									
Daily amount[11]	Low to high	Low	Low	Low	Medium	Medium to high	Low	Low	Low
Amount per kWh/year[9]	High	Low	Low	Low	Medium	Medium	Low	Low	Low
Land use:									
Areal extent[6]	Low	High	High	High	Medium	Medium	Low	Low	Low
Power density[6]	Medium to high	Low	Low	Low	Medium	Medium	High	High	High

[1] Engine-driven solar parabolic dish.
[2] Scale of OTA reference systems: Small = 25 MW; Medium = 25 to 100 MW; Large = >100 MW. For unit ranges associated with the terms, see table 4-2 (Characteristics Constraining Technology) and Storage Technologies, Types of Status and Applications.
[3] Short = <2 years, Medium = 2 to 5 years, Long = >5 years.
[4] Refers to the general ease of siting a powerplant. Siting is based on combination of geographical location, fuel availability, and environmental characteristics. Low = plant can be sited only at specific locations; Medium = plant can be sited at many locations, but is constrained by local resource availability, etc.; High = plant can be sited at most places with relative ease.
[5] Refers to the overall reliability of the powerplant, primarily daily resource variability.
[6] Levelized cost (1990$) under most likely case scenario. Low = <7 cents/kWh; Medium = 7-14 cents/kWh; High = > 14 cents/kWh.
[7] Rate-after technology can withstand a real rate of return over 15 percent in nonutility applications under most likely case scenario. Assumes no Federal Renewable Tax Credit.
[8] These potential environmental impacts are based on the reference plant sizes listed above and listed on direct impacts from onsite operation. Impacts associated with production of facility components, or disposal of waste components, are not considered.
Unless otherwise noted, the following rating (system) applies:
• High indicates substantial likelihood of large impacts requiring special measures to bring the facility into compliance with local, State, or Federal environmental protection statutes. "High" is also used to identify a strong potential for constraining land use elsewhere and problems resulting from competition for scarce resources (e.g., for water in arid/low-rainfall areas). In all of these cases, the resulting impacts could be serious enough to constrain full development of a site specific energy resource.
Where an extraction is concerned, a high rating may be more reflective of local air quality conditions than actual extraction rates. For example, location on a nonattainment area can affect development of any contractor — and large enough to fail under Federal standards.
• Medium indicates that some special measures may be required to bring the facility into compliance with environmental protection statutes, but these conditions are not likely to constrain total development.
• Low means that environmental impacts are expected to be negligible.
• Construction energy (i.e., low-high) indicates that: 1) impacts are likely to vary according to site-specific characteristics, and/or 2) impacts vary substantially with plant size.
[9] From daily plant operation only. Studies associated with production and/or replacement of plant components are not considered.
Most have only different challenges to surface water (e.g., toxics and nitrates), impacts on ground-water are not considered.
[10] Impacts could be greater if cooling towers would lead to increased sedimentation in nearby streams.
[11] As explained in the following two footnotes, these ratings reflect the amount of water used rather than the consequent environmental impacts of water use. In areas with limited water resources and/or large competition for existing supplies, technologies with a moderate rating under this category may have differing consequences.
Low = <1 million gallons per day; Medium = 1 to 3 gallons per day; High = >3 million gallons per day.
[12] Low = < 1,000 gallons per day per MW/annual; High = 3,000 to 20,000 gallons per day per MW/annual; High = > 20,000 gallons per day per MW/annual.
[13] These ratings are based on the land requirements for a 30 MW/annual plant. They suggest where potential problems may arise regarding visual impacts, competing land uses, or habitat disruption. Low = < 10 acres; Medium = 10 to 100 acres; High > 100 acres. While extensive habitat disruption could occur on a small area (e.g., a 10 acres), we have assumed that the affected area would be small enough that overall impacts on the ecosystem in question would not likely to constrain development.
[14] Refers to the amount of power produced per acre: Low = <50 kW per acre; Medium = 50 to 5 MW per acre, and High = > 5 MW per acre.

SOURCE: Office of Technology Assessment

New Electric Power Technologies: Problems and Prospects for the 1990s

DISCUSSION

Mrs. LLOYD. Maybe next time we'll let you go first, Doctor. [Laughter.]

Mr. BLAIR. I think that happened in the Senate, actually.

Mrs. LLOYD. You both provided excellent testimony, we appreciate it very much.

In your written testimony, Peter, you touched a great deal on the commercial applications of solar thermal and biomass. Now, certainly we all recognize that we're in the time of tight budgets. So do you feel that the marketplace should decide which technology should receive the highest budget priority, or do you think that it should be based on the merits of the technology? Where are we?

Dr. BLAIR. Well, I think it depends on the rationale. We are a bit schizophrenic in where we want to apply these technologies generally right now. Those that are the closest to commercial viability need that demonstration push. There is a gap between the proof-of-concept and the commercial availability. And several of the technologies are in that boat, I believe. Wind and photovoltaics being perhaps the closest to commercial viability as well as a range of biomass technologies.

Others that are on the R&D front—solar thermal—we're not likely to see for a while unless there is a major demonstration push. Yet, it's important to keep that basic research alive. So I think one needs to distinguish between the basic research required for those earlier technologies and the demonstration push for those that are closest to commercial viability.

Mrs. LLOYD. As a follow-up, are you aware of any other countries that have substantial R&D programs in biofuels and solar programs?

Dr. BLAIR. Well, in solar programs, take the photovoltaics , perhaps, as a push, I think we are quickly in danger cf losing the photovoltaics market to the Japanese. They have capitalized strongly on the niche markets for consumer electronics and remote applications. Only several U.S. companies are even considering that in their incentives and, therefore, they have to have the wherewithal to hang in there until good, connected electric-power markets appear.

The Japanese, on the other hand, are using the niche markets to develop the commercial viability of the technology and will be very strong competitors very quickly.

Mrs. LLOYD. Did you know this Administration has not been very courageous in demonstration programs? They have had a certain degree of hesitancy. In our coal programs we have seen some movement toward demonstration, but this is the only area.

We do have a great drop in our energy research and development programs. In this scenario, do you think the Federal Government should provide demonstration funds?

Dr. BLAIR. Well, I believe if the objective is to accelerate the commercial viability of these technologies, then demonstrations will be essential. And a Federal role in those demonstrations is essential to bringing them about quickly.

Mrs. LLOYD. Thank you very much.

Mr. Fawell?

Mr. FAWELL. Thank you.

The only question I have—I didn't quite follow your fourth point in regard to changing economic landscape having a detrimental effect. Would you run through that?

Dr. BLAIR. Sure.

Several points—some research over the last decade has sort of infused, perhaps, the role of energy-efficiency improvements. I cited early on perhaps in my remarks that the dramatic change—some researchers attribute entirely to energy efficiency improvements. I read one report recently where we took the energy to GNP ratio in the early 1970's and applied that to the GNP in the mid-1980's one that allows us to compute the energy we would have computed had that energy to GNP ratio been in effect during that period.

That, of course, assumes that all of that change comes about as a result of energy-efficiency improvements. The fact is that we've had a dramatic change in our economic landscape over that period, so much of it has to do with the change in the market baskets of products we make; the move toward a more services-oriented economy; decline, perhaps in or changes in the kinds of manufactured products we produced: specialty steels instead of bulk steels, and the like. So that the changing role of our industry puts different demands on energy supply.

Mr. FAWELL. Thank you.

That's all the questions I have.

Mrs. LLOYD. Thank you very much, Dr. Blair, for being with us. We always enjoy having you appear before the Committee. Wish you a nice holiday.

Our next witness is Scott Sklar, who is Executive Director of the Solar Energy Industries Association. Scott is also a familiar face to our Subcommittee. We welcome you back.

STATEMENT OF SCOTT SKLAR, EXECUTIVE DIRECTOR, SOLAR ENERGY INDUSTRIES ASSOCIATION, ARLINGTON, VA

Mr. SKLAR. Thank you, Madam Chairwoman.

I brought charts today—4,000 words worth of charts.

Mrs. LLOYD. Very good. We look forward to your charts.

Nancy is having to perform double duty around here today.

Mr. SKLAR. Thank you.

Mrs. LLOYD. But she does well.

Mr. SKLAR. On behalf of the Solar Energy Industries Association, which is the trade association for both the solar thermal and photovoltaic manufacturers. I'd like to thank the Subcommittee for the opportunity to testify and we'd like to strongly endorse H.R. 4226.

The proposed legislation, supported by the Chairwoman and Congressman Sharp——

Mrs. LLOYD. Scott?

Mr. SKLAR. Yes?

Mrs. LLOYD. Excuse me. We have to take time out for a commercial. We've got to go vote again.

Mr. SKLAR. Okay.

Mrs. LLOYD. But I think it might be better if we would go ahead right now instead of interrupting you in the middle of your testimony.

Mr. SKLAR. Okay.
Mrs. LLOYD. We'll go and come right back, all right?
Mr. SKLAR. Okay, that's fine.
Mrs. LLOYD. Thank you.
Mr. SKLAR. No problem.
Mrs. LLOYD. The Subcommittee's in recess.
[Recess.]
Mrs. LLOYD. The Subcommittee will resume our hearings. And, Scott, you may proceed.
Mr. SKLAR. Thank you, Madam Chairman.
As I stated before, we do support H.R. 4226. We think it is a very, very important turn of policy to promote renewable energy through multiyear funding and some other kinds of directives.
The Committee asked us what other countries are doing in terms of R&D. And I'd like to point out again to the Committee that while photovoltaics were cut from $153 million in 1981 to 35 million in 1989, Japan is spending $61—sorry—Germany is spending $61 million compared to our $35, and Japan is spending $43 million compared to our $35.
If the appropriations in OMB numbers were followed suit and went down to $24 million, our budgets compared to Germany and Japan would not make any difference; it would have been worth closing down the program.
The solar thermal budgets are the same. It was $120 million in 1981; is now $15 million in 1989. Our international competitors—Phoebus, which is a consortium of countries—Sweden, Switzerland, Spain, and Italy—are promoting stretch-membrane concentrator technology.
The European Economic Community directs more than five times more funding towards export assistance for renewables than does the United States
Mrs. LLOYD. Would you just for a—I'd like to look at that last chart.
Mr. SKLAR. Okay.
It was just color coded in regard to where the renewables were in FY 1981 to where they are in FY 1988. As you can see, that's a rather drastic downward slope.
Mrs. LLOYD. Okay, thank you.
Mr. SKLAR. Okay. And then the follow-up graph is sort of over the same time period where we really are versus the International Energy Agency countries, which is mostly all Western countries. And as you can see, these are total renewables budget funding of the United States versus IEA. But what's happening—although while we had precipitous cuts in 1981, obviously, and we slope down; IEA's is starting to pick up now in 1986, and it's going up that way and we're going down that way. And that's not in all technologies. Again, Japan has surpassed in photovoltaics. India and the Netherlands surpass in wind. Sweden and India's—and Japan, surpassed us in biofuels. So there are different countries picking on different technologies because of their own indigenous industry or resources, or relations abroad.
What I have mentioned when I testified before this Committee before, I know this—we are going to get into VCR syndrome. And I put it as where America gives away its technological predominance

in a technology only to purchase it back years later for millions or billions more than it originally took to develop it.

And I am very nervous that if this bill does not become law—and it is an important bill—that you will be seeing a lot of our domestic industry bought by our international competitors, and either the technology taken abroad and purchasing as was stated before. Just like we are importing oil, we'll be importing renewables. That doesn't make sense.

This is a very young industry. It's less than 15 years old. It is mostly composed of small business. It is under-capitalized. It's very, very young. It's like the computer industry in the 1940's or 1950's.

So some of the ideas in terms of joint ventures, I wanted to remark on because I think it's very important for you to be aware of how I think and how the industry thinks it may work.

One, the idea of brokering a project with Federal and private monies is good energy policy, and it will attract new capital under a capitalized industry. Surely, Government-supported projects are not the way to go. I agree with Mr. Hubbard in that. However, because it's a small business industry, and because it's under-capitalized, we need to do a few things.

First, we must encourage State and local government contributions as part of the joint venture. Already States are giving their Exxon overcharge monies and other State monies to renewable energy ventures because it will create employment, or it will build some high-tech industries. And we can see in California, Massachusetts, Texas, Florida—States that have been very active in developing renewable energy industry joint ventures.

The second thing that would be very useful is to allow the industry to use other than cash contributions to be part of the joint venture. In other words, to give donations of labor, land, or licensing. That will make the industry more able to buy into a joint venture.

Third, we need to attract other Federal entities. We're finding in the solar industry that HUD for housing projects, Department of Defense for domestic military bases, are very interested in entering into some kind of joint venture agreement. And that it's be important, not just for DOE, but for the Federal Government to look at how you develop that interagency joint venture —that might make it work.

The fact of the matter is that joint ventures can attract money. It can save the Government money from anteing everything; and it can make sure it's real in the private sector. But at least my three suggestions are very important.

Next, I just wanted to lay out some of the technical objectives of the Department of Energy program. It is to long-term, high-risk R&D for the way the industry is. You need to have an expanding domestic market to compete internationally. You need to have an existing industry infrastructure, as Dr. Blair said, to be around in the future. We are in neither camp. To build that we need to look at dual track—short-term and long-term R&D.

And the fact of the matter is that the program so far has been very successful. And I brought a—my final chart for you. This is a graph that came out of a Department of Energy publication, but just shows in the five years in the photovoltaics program, we have brought down price and efficiency, or cost of production of photo-

voltaics, and their efficiency increased dramatically. And that—in five years time, and a real partnership with industry and Government. And this is the kind of program that works. We need to broaden that to all the renewable programs in DOE, not just photovoltaics. But it has worked very well.

And just some efficiencies—we've had a multijunction cell efficiencies; have broken new records in 1988 of 12.4 and 13.3 percent this year. And we have met every efficiency and cost goal over the last five years.

In the solar thermal program, we hit a concentration rate of 60,000 suns. We can now power lasers—and will have some important aspects for this technology in the military world.

Dr. Hubbard was a little, I think, cautious on the potential for waste cleanup. And at least in a meeting I attended two weeks ago in Santa Fe and this Fourth International Conference on Solar Thermal Technologies, a presentation was given on dioxin breakdown; that if you heat a dioxin solution 800 degrees, you break down a 99.4 percent of the dioxin is gone. Unfortunately, 99.4 percent isn't good enough for EPA.

If you do the same 800 degrees under concentrated sunlight, it will be 99.999 percent breakdown. And we're finding out that chemicals react differently under sunlight, in addition to heat.

Sandia and SERI will be doing tests now to take a look at the modeling work that's been done on this to prove it in the field. But I think that you will be seeing in the next few years that solar thermal technologies are going to be a major player in both hazardous waste breakdown and development of stronger and durable materials, and processing.

I have a final concern, and the final concern is that the portions of the bill that promote export assistance is essential; the reauthorization of the CORECT process as Federal interagency board that promotes exports is very important for us. Sixty percent of our sales in photovoltaics are overseas now in the Third World, and it's very important that this part of the bill be maintained.

I particularly want to thank the Committee and I'd like to thank the Chairwoman for supporting this bill, because I think it does resurrect a renewable energy in the United States. And I hope this this bill will be marked up this year.

Thank you.

[The prepared statement of Mr. Sklar follows:]

SOLAR ENERGY INDUSTRIES ASSOCIATION Suite 610 1730 North Lynn Street Arlington, Virginia 22209-2009 (703) 524-6100
FAX: (703) 527-2833

TESTIMONY

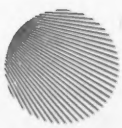
by

SCOTT SKLAR
EXECUTIVE DIRECTOR
SOLAR ENERGY INDUSTRIES ASSOCIATION

before

SUBCOMMITTEE ON ENERGY RESEARCH & DEVELOPMENT
HOUSE COMMITTEE ON SCIENCE, SPACE, & TECHNOLOGY

JUNE 30, 1988
WASHINGTON, D.C.



INTRODUCTION

The Solar Energy Industries Association, the national trade association representing the photovoltaic and solar thermal manufacturers and component suppliers, strongly endorses the "Renewable Energy and Energy Conservation Commercialization and Development Act" (H.R.4226). The proposed legislation introduced by both the Chairman of the House Energy & Commerce Subcommittee on Energy & Power and the Chairwoman of the House Science, Space & Technology Subcommittee on Energy Research & Development, represents an important attempt to resurrect a United States renewable energy and conservation policy. Introduction of this legislation is opportune in the face of increasing competition from abroad -- particularly by other industrialized nations who are our competitors and sense a lessening of resolve by the United States to commercialize our solar and renewable energy research.

In fact while the United States cut our photovoltaic research from $153 million in FY'81 to $35 million in FY'88, our strongest competitors Japan and Germany spend $43 million and $61 million respectfully. While the United States cut our solar thermal research from $120 million in FY'81 to $17 million in FY'88, our European competitor nations have established a consortium, Phoebus, to aggressively market this new technology abroad. And while the United States cut the solar buildings research from $75 million in FY'81 to $5 million in FY'88, the United States has one million solar hot water systems while the City of Tokyo alone has that number. The European Economic Community directs more than five times more funding towards government supported renewable energy export promotion than does the United States.

Unless the U.S. research priorities are refocussed, the United States may face a replay of the "VCR Syndrome". Simply put, "VCR Syndrome" is where America gives away its technological predominance in a technology only to purchase it back in later years from our competitors for millions, if not billions, of dollars more than you orignally paid to develop the technology. The Administration's research philosophy to fund long-term, high-risk research involving an industry that is primarily composed of small businesses and is under-capitalized, is not a good strategy for the solar and renewable energy industries. H.R.4226 represents an important step towards redirecting our government programs towards pushing research to market development -- a step that's truly needed.

STATUS OF THE UNITED STATES SOLAR INDUSTRY 2

The United States photovoltaic industry annual terrestial sales hover around $200 million per year. Currently, over sixty percent (60%) of U.S. technology is exported and our companies have nearly half the world market. However the drop in U.S. world market share from eighty percent (80%) in 1981 to fifty percent (50%) in 1988 is not just due to an expanding international market. Our international competitor nations are much more strongly supportive of their industries to capture international markets.

The United States solar thermal power industry has annual sales approaching $150 million. Over 160 MW of electricity of solar thermal power is now produced in California. Several large commercial-scale industrial process heat applications are operating throughout the United States. As mentioned earlier, the governments of Spain, Sweden, Germany among others in partnership with industry have established Phoebus, a consortium to market stretched membrane technology worldwide, primarily to North Africa. Although the U.S. developed and leads in this technology, only limited resources have been made available by the U.S. Congress to commercialize this important technology. Not only has the use of stretched foils dramatically brought down the cost of electrical generation, but the technology has also near term use for toxic waste destruction and power production for the space station.

Solar hot water technology sales have topped $100 million in 1987 and sales should increase substantially in 1988. Purchases of solar hot water systems in the pool heating and new home construction markets are the main reasons for the sales increases. Efforts by industry to increase sales through federal and state government procurements and incorporation of solar in conventional housing loan programs (FHA,VA,FmHA) could double sales within the decade.

The United States photovoltaic, solar thermal power and solar hot water industries are growing despite low energy prices, expiration of tax incentives, and lessening federal support in R&D and loan-subsidy programs. However this growth rate is dwarfed by the growth of our competitors who have greater government support in a myriad of areas. Other governments have more collaborative federal R&D programs with the goal of short-term commercialization.

FEDERAL GOVERNMENT PROGRAM SUPPORT & GOALS

Our international competitors are salivating at the prospect of a U.S. retrenchment in solar and renewable energy development. Many international experts conclude that a multibillion dollar market exists for renewable energy R&D. The U.S. industry needs a stable and supportive federal R&D program. H.R.4226 establishes a set of multiyear R&D levels which the Solar Energy Industries Association heartily endorses. The multiyear authorization levels for photovoltaics, solar buildings, solar thermal power, and internation (CORECT) export activities are adequate and represent a reversal of policy. Earlier, the Administration and Congress have sought to cut these programs to comply with Gramm-Rudman -Hollings even though such cuts would place these programs in a closeout mode.

The technical objectives of the U.S. Department of Energy programs have been met. For instance, all of the cost and efficiency goals of the first PV five-year plan have been met or exceeded. The industry has every expectation to exceed cost and performance goals in this newly instituted US/DOE five-year plan. Efficiencies in amorphous silicon multijunction cells have broken new records in 1988 at 12.4% and 13.3% respectively.

In the solar thermal power program, a new record in solar thermal concentration has been achieved through work supported by the Solar Energy Research Institute. A solar intensity of 60,000 suns has been achieved, which is greater than any previous attempt, leads the way to energizing lasers, development of stronger and durable materials, and disposing of hazardous wastes, chemicals, and nuclear fuels. Stretched membrane technologies has cut the weight by a factor of three cutting materials costs in half. In solar buildings, technical tools are now available to predict thermal performance of both passive solar features and active solar heating equipment. These predictors will allow architectural, design, and engineering firms to accurately incorporate this equipment in commercial projects.

While the U.S. interagency export coordination effort, the Committee On Renewable Energy Commerce and Trade (CORECT) has been well managed by the U.S. Department of Energy, the level of support must be broadened. The $1.5 million level for international export promotion is the bare minimum to carry out a successful effort. CORECT's goals and administration are sound. Close cooperation with the U.S. Department of Commerce is essential to insure that the activities are market oriented.

From the solar industries' perspective, the technical goals of the US/DOE programs are sound and do not need to be modified. The Administration's policy of support of mainly long-term, high-risk research is not sound and must be redirected. The requirements of H.R.4226 which direct the U.S. Department of Energy to report to the U.S. Congress on their technical performance goals and to develop a strategic plan are important as a way to insure that the programs remain relevant and to increase Congressional oversight and understanding. However, the U.S. Congress, in fact, ought to direct the Department of Energy and the Office of Management and Budget to make these recommendations and plans in response to Congressional objectives in addition to their own.

JOINT VENTURES - COMMERCIAL DEMONSTRATIONS

The establishment of a special joint venture fund to promote solar and renewable energy projects are laudable. Government-supported demonstration projects have had limited utility because many of the companies involved did not have an economic commitment to the projects' long term operation. The idea of brokering a project with federal and private sector monies is good energy policy. Such ventures will attract new investment capital to this undercapitalized industry.

However, I wish to make some recommendations to broaden the scope of the joint venture provisions in H.R.4226 that will make it more useful in the marketplace. First, allow state and local government contributions to offset industry contributions. In this way, many small businesses that have developed useful solar technology but lack resources could qualify if the state or local governments believe in its applicability or because the venture builds the local economy.

Because the solar energy industry is predominantly small business, in-kind contributions including donations of labor, land, and licensing must be included as part of the industry contribution to the proposed joint venture. Since the majority of solar companies are less than fifteen years old and do not have the assets, capital, or other collateral that older, more coventional industries have -- in-kind contributions are an important aspect.

Finally, coordination of joint ventures with other federal entities including the Small Business Administration, Department of Commerce, Department of Housing & Urban Development, Department of Defense and other federal entities would greatly increase the success of these projects. If these joint ventures can leverage funds from other federal agencies which fit into their mission or program goals, these projects will more easily attract private capital.

The joint venture proposal in the legislation is worth Congressional support because it develops the kind of industry/government partnership so important if the U.S. solar industries are to compete successfully in the international arena. Our industries cannot hold world markets if we are unable to maintain a sizeable and expanding foothold in our own domestic markets.

CONCLUSION

The Solar Energy Industries Association (SEIA) strongly endorses the "Renewable Energy and Energy Conservation Commercialization and Development Act". H.R. 4226 exemplifies an important Congressional policy initiative to reorient the U.S. federal research and development program away from esoteric R&D to practical R&D that will help U.S. industry build our international markets.

The directives in the legislation to require the U.S. Department of Energy to report to the U.S. Congress on their technical performance goals, developed in consultation with industry, is a useful tool to focus the program. Further requirements to establish a solar and renewable energy strategy in the National Energy Policy Plan is also useful since solar energy has been receiving decreasing attention in that plan.

Joint venture projects will be useful if industry in-kind contributions are allowed to offset capital contributions. In addition, federal agencies other than US/DOE and state and local governments should also be allowed to "buy down" the industry contribution. In this way, the predominantly small business solar industry will be able to successfully join such government/ industry partnerships and attract capital.

Finally, the multiyear authorization levels for photovoltaics, solar buildings, solar thermal power, and international export promotion, are essential if the U.S. industry is to be secure and maintain our technological predominance internationally.

U.S. DEPARTMENT OF ENERGY SOLAR & RENEWABLE ENERGY R&D APPROPRIATIONS FY'81 - FY'87

Prepared by Scott Sklar

October 1987

	FY'81	FY.82	FY'83	FY'84	FY'85	FY'86	FY'87	FY'88
BIOFUELS	57.7	30.5	21.0	28.4	31.0	27.3	24.0	17.0
WIND	83.7	34.7	31.4	26.5	29.1	24.8	16.7	8.1
PHOTOVOLTAICS	153.2	78.0	58.0	50.4	57.0	40.6	40.4	35.0
SOLAR BUILDINGS	74.9	22.1	11.7	16.4	9.9	8.2	5.9	5.2
SOLAR THERMAL	119.9	54.9	49.5	40.8	35.5	25.8	22.9	17.0
INTERNATIONAL	12.0	4.0	10.0	15.5	0.5	0.9	0.8	7.5
TOTAL	$557.1*	$276.4	$201.6	$179.6	$165.	$144.6	$123.5	$96.9

NOTE:

1. Numbers express in "millions of dollars".

2. Budget line-item include operating expenses and capital equipment and are rounded off to the nearest decimal.

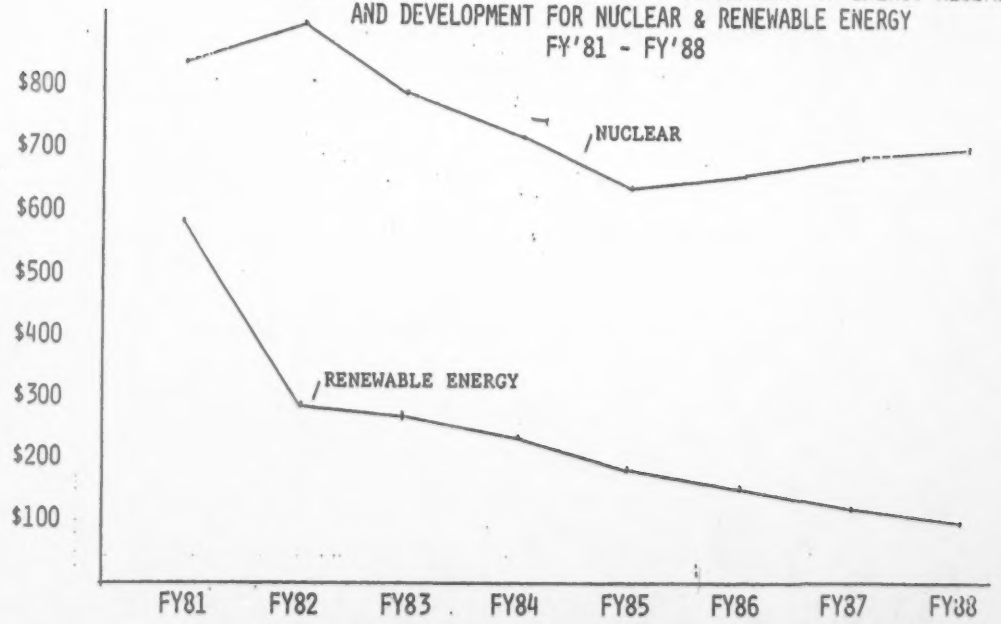
3. Total renewable budget does not add due to other line items not included such as SERI, Resource Assessment, Program Support, Program Direction and fiscal year carry-overs, etc.

4. Biofuels figures combine alcohol fuels and biomass line items in early fiscal years since programs were combined later.

5. Solar buildings figures combine passive and active solar line items in early fiscal years since programs were combined.

(*) FY'81 program was $220 million larger due to other programs not carried out in later years regarding commercialization and public information programs.

ACTUAL APPROPRIATIONS FOR U.S. DEPARTMENT OF ENERGY RESEARCH AND DEVELOPMENT FOR NUCLEAR & RENEWABLE ENERGY FY'81 - FY'88



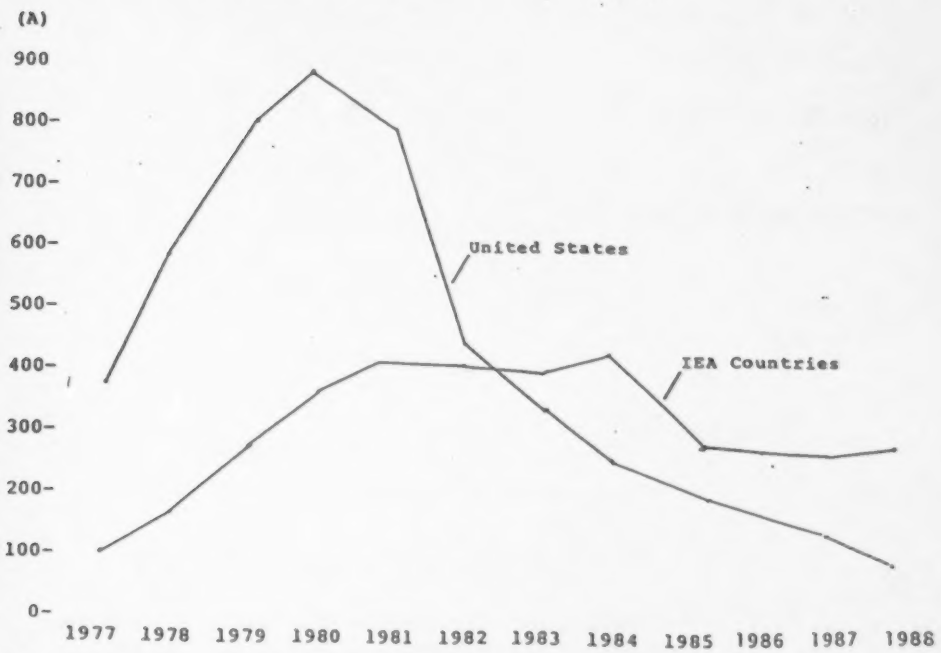
NUMBERS EXPRESSED IN MILLIONS OF DOLLARS AND ARE ACTUAL CONGRESSIONALLY-APPROVED APPROPRIATIONS FOR RENEWABLE ENERGY AND NUCLEAR ENERGY

RENEWABLE ENERGY INCLUDES SOLAR BUILDINGS, SOLAR THERMAL, PHOTOVOLTAICS, BIOFUELS, WIND, OTEC, SERI, TECHNOLOGY TRANSFER

NUCLEAR ENERGY INCLUDES NON-MILITARY US/DOE R+D PROGRAMS AND NOT INCLUDING AVLIS OR NUCLEAR WASTE REPOSITORY ESTABLISHMENTS

VARIATIONS MAY OCCUR REGARDING CARRY-OVER MONIES AND THE INCLUSION OR OMISSION OF CERTAIN LINE ITEMS BUT OVERALL NUMBERS ARE CORRECT

US/IEA GOVERNMENT R&D BUDGETS FOR RENEWABLES IN 1985
US DOLLARS (1977-1988)



IEA COUNTRIES: Australia, Austria, Belgium, Canada, Denmark, Germany, Greece, Iceland, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdon

AXIS (A): In millions of U.S. dollars

RENEWABLE ENERGY ELECTRICAL GENERATION IN THE UNITED STATES AS OF MARCH 1988

Anaerobic Digestion	17.94 MW
Geothermal	1,578.80 MW
Landfill Gas	49.82 MW
Municipal Solid Waste	630.60 MW
Photovoltaics	13.27 MW
Solar Thermal Power	110.25 MW
Wind	1,223.20 MW
Wood/Agricultural Waste	3,189.26 MW
TOTAL	6,813.14 MW

* Does not include hydropwer (approx 73,000 MW)

** Does not include plants under construction (approx 2,500 MW)

*** Does not include conservation and energy management applications installed with renewable eergy options

DISCUSSION

Mrs. LLOYD. Thank you very much, Scott.

In addition to the three-year funding aspect, how would solar programs benefit with the passage of this bill?

Mr. SKLAR. Well, three ways: one, as Dr. Hubbard said, it provides some stability. It's hard to attract capital in the private sector with a small industry if the Federal Government is sort of going zigzagging or going down. If there's just some steady program direction, we're going to get some support.

Secondly, on the export assistance, I have said to this Subcommittee before, dollar for dollar it's the most valuable program we have as far as short-term market development. And by maintaining and reauthorizing this international activity, we're sending a signal abroad that we're committed.

Lastly, we have not been able to achieve an intelligent way of joint venturing projects.

Mrs. LLOYD. Would it add credibility to our program?

Mr. SKLAR. That's right. And so by developing with industry and the Congress some approach to project development, I think that will put is on the healthiest path we've been on in a long time. So we're very encouraged by this.

Mrs. LLOYD. And it would help your technology transfer?

Mr. SKLAR. Absolutely, because the other issue is, you can do great things in the laboratory, but if we cannot get it to the private sector to use, it's not going to be worth much. So this effort is to get it to the people.

Mrs. LLOYD. Has the Committee on Energy, Commerce and Trade served its purpose intended? As you know, it authorizes funding for this.

Mr. SKLAR. Yes. What CORECT has done is it has brought together 15 Federal agencies or entities together to coordinate export promotion. They have provided a series of materials that we can use abroad. They have developed a design assistance center so we can use the Federal labs to be the third-party endorser of design work for customers overseas.

They have been very useful in getting the industry to travel overseas to potential markets. We've sent teams to the Caribbean, to Southeast Asia. And I believe that we're going to see sales—and we have seen sales generated—but we will see it exponentially generate over the next few years from this activity.

Mrs. LLOYD. Very good.

As you know, DOE is a little bit cool to this legislation—from the information that's available to me.

How well does the DOE technology transfer programs work for renewables—the programs we have in place?

Mr. SKLAR. Well, they work. And, you know, part of the problem again is using the bully pulpit to promote the program. And in my view, OMB has not been a positive actor in this. I believe DOE has, and I think Donna Fitzpatrick has supported our programs pretty well—but other than on the funding levels. They're a team player.

But the fact of the matter is that we need a very, very aggressive approach to transfer technology out of the laboratories. And some of that, honestly, has been a credibility problem up here. I've been

asked many times by a Member of Congress, how do I—you know, well, we fund these technologies; I'm not seeing it in the marketplace. You know, we've done this 10 years ago.

Mrs. LLOYD. Well, you know—says we don't need this program.

Mr. SKLAR. That's right.

Mrs. LLOYD. Says that it's not necessary.

Mr. SKLAR. Well, the issue is it's very necessary because no one in the policy side is going to continue funding if they don't see an effective way to transfer the technology to the private sector, and so it is essential to make the transfer. You know, SERI is a very important institution for our survival. But if the financing is not available on the promotion, to take their work and get it to the private sector, there's some question of utility over all the whole program. And so that's what we're trying to do, and the industry has been fighting OMB on this. We think it's ideological and not proven.

Mrs. LLOYD. In your charts you showed how that we're spending less on our R&D than our international partners. What can we do to maintain our leadership in this austere budget climate?

Mr. SKLAR. Well, you know, I think you're on the right track with the legislation. Obviously, we're not saying you need to double the budget, you know. We're pragmatic. I think what industry is saying is keep us level, use—attract outside capital, and under this—and by using the joint venture approach of putting up some money to attract money will attract capital, and give us some minor assistance on export development so we can go after some opportunities abroad. So the legislation is sound that way, and I think it answers your question of how do we continue the U.S. effort without breaking the budget. You know, I think you have something to do that.

Mrs. LLOYD. Thank you very much.

Mr. Morrison.

Mr. MORRISON. Just a short question.

Scott, I'm sure the Association, as you look around the world, have seen some examples of excellent mechanisms to coordinate the research development marketplace and really taking the technology out to the world's shelves.

Do you have some feelings from that as to different steps we should take as a Nation to bridge this gap?

Mr. SKLAR. Yes I do. Some of it is not necessarily in our character and so I accept that. But in watching the Japanese in pushing renewable technology, they have done nothing sleazy. They've played it very intelligently. One obviously is that there's greater cooperation with industry and Government in just developing a strategy. And I think we have that in this country anyway. I'm particularly talking on the photovoltaics program. We are about as close and as cooperative with the Federal Government developing our R&D strategy as can be under the law.

Mr. MORRISON. You're a new industry and not as ingrained perhaps as some other energy developments.

Mr. SKLAR. That's right. But the real issue is how the Government then can use the other sectors of the Government to access capital. You know, it's again, because we're a young industry, the companies and members of my association cannot, you know, do

not have land and oil wells and, you know, other things that the conventional energy industry has that they can use to collateralize loans—or the history the conventional energy industry has to get capital. It's just not there.

In Japan and in Germany, in particular, but in Italy and now coming into Brazil, we're starting to see the governments are really making capital accessible, tied to their R&D efforts, and we need to work on that. And in some cases this goes beyond the jurisdiction of this Subcommittee, but unless we can tie our research goals and our market development to capital, it's not going to happen. And we're not the only technology sector that suffers from the problem. This is a major problem in the United States right now, particularly the long-term technology development.

Mr. MORRISON. Would it be important, in your view, to, in the capital arena, to give whatever we do there, the extra incentive of having this be in the energy area?

Mr. SKLAR. Yes, and in some ways why the joint venture part of this bill is so important, is that maybe we can develop some working models using State, Federal and industry money to do that. Again, the industry is also nervous of just doing demonstrations for demonstration's sake. We find that doesn't build your market. But doing demonstrations that basically all you're doing is buying down the risk a little bit and attracting a broad consortium of individuals and companies we think will go a long way for us.

Mr. MORRISON. Because we sort of have our choice here—and I'm not sure either is a real potential. But I have a major capital gains change in that would apply to all investment.

Mr. SKLAR. Uh-huh.

Mr. MORRISON. Or we could go a different route and try to specialize so that we did just those areas of priorities, such as renewable resources.

Mr. SKLAR. I would think so, yes, you know. And the other question I was asked earlier by one of the other Congressmen, in terms of discussing market costs of energy versus some of the environmental concerns, that it may pay, that on some of the other developments in terms of controlling pollution or carbon dioxide or dispersed energy development, you could build in those incentives.

Mr. MORRISON. Thank you.

Mrs. LLOYD. Thank you very much, Mr. Morrison.

Mr. Stallings?

Mr. STALLINGS. No questions.

Mrs. LLOYD. Thank you for being here.

Thank you, Scott, for your testimony. We appreciate your being with us today.

Mr. SKLAR. Thank you, Congresswoman Lloyd. Thank you.

Mrs. LLOYD. We'll work for passage of this bill, if possible.

Mr. SKLAR. I hope so.

PANEL

Mrs. LLOYD. Our final witnesses will appear together. Dr. T.W. Fraser Russell, who is Director of the Institute of Energy Conversion at the University of Delaware; and Mr. Geoff Crandall, who is

a representative from the National Association of Regulatory Utility Commissioners.

Dr. Russell.

STATEMENT OF DR. T.W. FRASER RUSSELL, DIRECTOR, INSTITUTE OF ENERGY CONVERSION, UNIVERSITY OF DELAWARE, NEWARK, DE

Dr. RUSSELL. Thank you, Madam Chairman, Members of the Subcommittee. I appreciate being asked to testify before this Subcommittee and I enthusiastically support H.R. 4226.

Your Subcommittee has been at the forefront in advocating Federal policy for research and development that recognizes the essential role that renewable energy and conservation must play in national energy policy. What I would like to do is to give you some of the flavor of an academic institution's role and viewpoint in this important area.

I am Director of the Institute of Energy Conversion at the University of Delaware, and also chairman of its department of chemical engineering. The Institute of Energy Conversion is a laboratory that has been devoted to thin-film photovoltaic cell research, and we've existed for about 15 years. It was established before the first OPEC embargo and before the formation of either the Department of Energy or the Solar Energy Research Institute. And we have produced hundreds of technical papers, many of which have had a major impact on industrial research. We have 23 patents, but we're most proud of the fact that we have produced some 40 professionals, engineers and scientists, who are having an impact on a growing photovoltaic industry, and this is a major role that universities need to play. And unless we have the funding to do this, we can't produce the people who can do the creative work and do the engineering necessary to bring these projects into commercial fact.

Most of the engineers and scientists that we have educated work in various large and small firms, as Mr. Sklar has indicated, but two of them have started their own photovoltaic manufacturing firms and have brought some several tens of millions of dollars from the commercial sector to do this.

We contribute to meeting the performance goals for the photovoltaic advanced research and development effort, which is set forth in the Department of Energy's five-year research plan. We still are trying to stress a need to include low-cost manufacturing in DOE's agenda for research and development.

We have received some $15 million in Federal funds since our inception, and we have matched this with some $8 million from other sources, for a total of $23 million, and I'd like to indicate to you that it's possible for an academic institution to do some cost sharing.

Madam Chairman, we're closer than the Solar Energy Research Institute. If you and Members of the Committee would like to visit, we would be very pleased to have you.

Mrs. LLOYD. I think——

Dr. RUSSELL. We also can provide real oysters, not the pale kind that they raise in the Rocky Mountains.

Mrs. LLOYD. I think we'll have to pack our bags pretty soon.

Mr. MORRISON. I think so. Dr. Hubbard is still in the room, though, I might note. [Laughter.]

Dr. HUBBARD. Yes, and he's a subcontractor to us, too. [Laughter.]

Dr. RUSSELL. That's true. We're one of SERI's major subcontractors.

I agree with most of what Dr. Hubbard has said—in fact, practically all of it. But I do think there's an academic view that needs to be stated, and I will confine my remarks to the development of photovoltaic technology and, in particular, the effects of the mutliyear authorization in commercial demonstration.

A photovoltaic or solar cell is a solid-state device which produces electricity directly from the sunlight. It, of course, has no moving parts, it requires no fuel, no cooling water, and produces no effluent to foul either the air we breath or the water we drink, and as a couple of previous testimonies have indicated, it's becoming a crucial issue worldwide. In fact, this Committee has been looking at the warming trends issue and the so-called "Greenhouse Effect" in this last couple of days. And as Congressman Fawell brought up, these are issues which are hard to put a cost on. But I don't think we can continue to use stored solar, which is fossil fuels, and put carbon dioxide, also some methane and other materials into the atmosphere. It's an experiment we don't want to carry out because, by the time we've seen the results of it, it's too late to do anything. So that this renewable energy research is exceptionally important.

Research effort in photovoltaics is meeting all the performance goals outlined in the Department of Energy's five-year plan. There is a growing private investment. Domestic and worldwide markets are developing for special applications in remote locations, as well as for reasonably large-scale power generation. There is some 6 to 8 megawatts grid-connected photovoltaics in California. The reliability of photovoltaic systems has both been demonstrated in space applications—and you can see half-a-dozen photographs in this room—as well as large terrestrial-power generation. The industry is creating interesting and challenging jobs for American workers. And it's an integrated high-technology effort and both the device and inexpensive manufacturing produces technology which may well be applicable in other industrial sectors, including such things as superconductors.

While the gains that the photovoltaic community has made have been impressive, they would have been even more so had we had stable funding over the past two decades. To have it drop from $150 million down to $35 or $40 million over a period since 1981 has been very difficult for those of us who try to manage research.

It is a small industry and only the Federal Government can provide the stable environment for the research which leads to eventual commercialization, and only th. Federal Government can provide the funds which lead us in the academic world to educate the engineers and scientists.

This is particularly true when the benefits are long range, and the benefits have to do with running out of oil, have to do with the environmental situation, and the Government needs to play a role. Long range in this case could be a decade or so. There are social, political implications that the other sectors of our society have dif-

ficulty to deal with. People in Congress, the staff, and the representatives know how to deal with these issues, and we need help in that area. The photovoltaic community has shown it can work efficiently and is able to plan to meet its technical goals. In fact, the photovoltaic research and development effort for program planning and program management can well serve as a model for other programs in renewable energy.

The stable funding proposed by the bill is essential for effective efficient research at both academic institutions and industrial organizations. It takes us between three and five years to produce a Ph.D.-educated person, and if the funding is erratic, it becomes very difficult to attract young people into this area and they will go elsewhere. And Dr. Hubbard made a remark earlier in which he said the technology can't come riding over the hill; it certainly can't. The timescale for education is three to five years and we have to add to that a timescale for research with people who already hold that amount of education. So we have to take action now if we're going to solve some of these problems.

Erratic funding also sends a message to industrial firms and their customers that there may be something wrong with the technology. It is most encouraging to see that Congress understands that research and renewable energy requires commitments for multi-year funding.

I would make another recommendation, however. I think that 60 percent of the funds appropriated—and this is where I will deviate a little from Dr. Hubbard's view of the world—should be spent to conduct research at universities and industry, and that the remaining 40 percent should be used by DOE and its laboratories for program management and to carry out research.

Now, as both an engineer and educator of young people, I can understand Congress' desire to see some concrete results come out of money that they spend. But photovoltaic power generation systems already work. They have been proven reliable in dozens and dozens of applications, several of which have been operated for many years. Our most critical issue is manufacturing cost. You must be able to make modules cheaply, and they will be a commercial reality only when we can produce electricity for somewhere between about 10 and 20 cents a kilowatt hour, and as Dr. Hubbard has pointed out, we're at the point now where we're about 30 cents.

I believe this can take place by 1995, provided there are improvements not only in the efficiency of the modules but if there is development of a low-cost manufacturing technology. It's this issue that concerns me most. We often develop an innovative product, we sometimes carry out the basic science, and then we turn around and watch someone else exploit its technology, and then later, as has been pointed out, we import it back at a cost of both of jobs and money. So there are limited private and Federal funds. There always are. The PV community and the United States must be concerned with international competition, must produce quality modules cheaply and timely. And I believe it's in the spirit of the commercial demonstration provision of H.R. 4226 to include demonstration of competitive manufacturing technology for photovoltaic modules.

The special nature of PV technology also suggests an unconventional funding arrangement may be more appropriate, and I have proposed in my written testimony a phased financing of a cooperative venture which would require cost sharing from industrial firms but also from utilities.

In summary, I would like the Committee to consider the following recommendations. I wish that on page 3 of the bill that the phrase "in consultation with industry" should be modified to include "industry and academia". On page 3, under Commercial Demonstration Projects, I would like to see the issue of commercial viability of photovoltaics emphasize low-cost manufacturing technology, and to bring about rapid commercialization, a program of phased Federal funding of a cooperative venture among the photovoltaic community and electric utilities is recommended.

On page 4, Authorization of Appropriations, I think DOE should be directed to expend at least 60 percent of its appropriations for research on advanced research and development at universities and industries.

Than you very much. I'd be happy to answer questions.

[The prepared statement of Dr. Russell follows:]

STATEMENT OF

T. W. FRASER RUSSELL, DIRECTOR
INSTITUTE OF ENERGY CONVERSION
UNIVERSITY OF DELAWARE

FOR THE

HEARING ON H.R.4226
THE RENEWABLE ENERGY AND ENERGY
CONSERVATION COMMERCIALIZATION AND
DEVELOPMENT ACT

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH
AND DEVELOPMENT

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

Madam Chairman, members of the Subcommittee, thank you for inviting me to testify before this Subcommittee on Energy Research and Development of the House Committee on Space, Science and Technology on the "Renewable Energy and Energy Conservation Commercialization and Development Act," H.R.4226.
Your Subcommittee has been at the forefront in advocating a federal policy for research and development that recognizes the essential role that renewable energy and energy conservation must play in national energy policy. I trust that my comments and suggestions will prove helpful to your efforts.

I am T. W. Fraser Russell, the Allan P. Colburn Professor of Chemical Engineering, Director of the Institute of Energy Conversion and Chairman of the Chemical Engineering Department at the University of Delaware. The Institute of Energy Conversion (IEC) is a laboratory devoted to thin-film photovoltaic cell research and has been in existence for fifteen years. IEC was established before the first OPEC embargo and formation of both the Department of Energy and the Solar Energy Research Institute. We have produced hundreds of technical papers and we have twenty-three patents, but we are most proud of the fact that we have educated over forty professionals who are having an impact on a growing photovoltaic industry. Most of these engineers and scientists work in various large and small firms, but two started their own photovoltaic manufacturing firms. IEC contributes to meeting the performance goals for photovoltaic advanced research and development set forth in the Department of Energy's Five Year Research Plan for the National Photovoltaics Program while stressing the need to include low cost manufacturing in the DOE's agenda for research and development.

In my testimony, I shall confine my remarks to the relation of H.R.4226 to development of PV technology, in general, and, in particular, the effects of the provisions for multi-year authorizations and commercial demonstration.

Photovoltaic power generation systems are an essential part of our renewable energy options. A photovoltaic or solar cell is a solid state device which produces electricity directly from sunlight. A photovoltaic power generation facility has no moving parts, requires no fuel, no cooling water and produces no effluent to foul either the air we breath or the water we drink. The research effort is meeting the performance goals outlined in the Department of Energy's Photovoltaic Five Year Plan. There is a growing private investment. Domestic and worldwide markets are developing for special applications in remote locations as well as for reasonably large scale power generation. The reliability of photovoltaic systems has been demonstrated in space applications as well as large terrestrial power generation facilities. This industry is creating interesting and challenging jobs for American workers. The integrated high technology research effort in photovoltaic devices and their

inexpensive manufacture produces technology which may well be applicable in other industrial sectors.

While the gains that the photovoltaic community has made have been impressive, they would be even more so if we had had stable funding over the last two decades. With a new small industry, only the Federal government can provide the stable environment for the research which leads to eventual commercialization. The photovoltaic community has shown that it can work efficiently and that it is able to plan and to meet its technical goals. In fact, the photovoltaic research and development effort, program planning and the program management could well serve as a model for other programs in renewable energy.

Stable planned funding, as proposed by the bill, is essential for effective, efficient research at both academic institutions and industrial organizations. When the funding is erratic it encourages students and young professionals to turn their talents elsewhere. It also sends a message to both industrial firms and their customers that there may be something wrong with this technology. It is most encouraging to see that Congress understands that research in renewable energy requires commitments for multi-year funding. However, it is equally important that the funding be directed in such a manner as to enhance commercialization. To its credit, the managers of DOE's PV program recognized that development of PV technology is best served by having most of the research carried out by industry and universities. Unfortunately, institutional biases tend to favor in-house research and to regard research by industry and university contractors as procurement rather than investment. Therefore, I strongly recommend that the multi-year authorization for the Photovoltaic Energy Systems Program include a provision that at least 60% of funds appropriated be spent to conduct research at universities and industry. The remaining 40% should be used by DOE and its laboratories for program management and to carry out research.

As both an engineer and an educator of young people, I understand Congress' desire to see concrete evidence that demonstrates the results of research and provides feed-back to industry. However, I believe that the nature of such demonstrations for photovoltaics must be directed to the particular characteristics of the technology rather than the needs of program managers and contractors. Photovoltaic power generation systems work and they have proven reliable in dozens and dozens of applications, several of which have been operated over many years. The most critical issue is manufacturing cost. Photovoltaic power generation will be a commercial reality when PV systems are able to produce electricity for between 10 and 20 cents a kilowatt hour. This can take place by 1995 provided there are improvements not only in the efficiency and reliability of PV modules, but also development of a low cost manufacturing

technology. It is the latter issue that concerns me. U.S. firms have traditionally excelled at rapid development and introduction of new technologies through innovative products. However, too often we have seen these technologies appropriated by competitors who have been willing to make long term investments in manufacturing technology, beginning with R&D.

There are limited private and federal funds. The PV community in the United States must be concerned with international competition, must produce quality modules cheaply and in a timely fashion to meet society's need for clean energy. I believe that it is in the spirit of the commercial demonstration provisions of H.R.4226 to include demonstration of competitive manufacturing technology for photovoltaic modules.

A modification of H.R.4226 of the Commercial Demonstration Projects Section for the Photovoltaic Energy Systems Program may be necessary to allow for such an effort since photovoltaics already has established itself as one of the most "appropriate technologies which can benefit from commercial integration."

The special nature of PV technology also suggests that unconventional funding arrangements may be more appropriate for a federally assisted effort to demonstrate commercialization of low cost manufacturing technology. For example, I would like to suggest a phased financing of a cooperative venture which requires cost sharing from both photovoltaic manufacturing firms and the utilities which will use PV power generation. The table below suggests a possible phased financing plan.

YEAR	1	2	3	4	5	10
Funding Percentage						
Federal Government	80%	70%	50%	30%	20%	0%
PV Manufacturing Firms	20%	30%	40%	50%	50%	60%
Utilities			10%	20%	30%	40%

Utilities begin to pick up their share of the cost when PV power generation units are placed in service. (demonstration projects)

This suggestion requires a high degree of cost sharing by the private sector, which I believe is essential for assuring that federal support is accompanied by long term commitment by participating firms to a commercial, non-government photovoltaic technology.

In summary, I am pleased to support the reaffirmation that solar energy is an essential component of national energy policy which can contribute to national security with minimal environmental risk provided for by the "Renewable Energy and Energy Conservation Commercialization and Development Act," H.R.4226. Multi-year funding is essential and will produce clean

electricity generation by photovoltaic conversion at a cost between ten and twenty cents per kilowatt-hour in 1995.

I hope that the Subcommittee will consider the following recommendations:

- Page 3 - Review and Update
  - the phrase in "consultation with industry," should be modified to include industry and academia
- Page 3 - Commercial Demonstration Projects
  - demonstration of commercial viability of photovoltaics should emphasize low cost manufacturing technology
  - to bring about rapid commercialization of photovoltaics, a program of phased federal funding of a cooperative venture among the photovoltaic community, and electric utilities is recommended.
- Page 4 - Authorization of Appropriations
  - DOE should be directed to spend at least 60% of its appropriations for research in the Photovoltaic Energy Systems Program on advanced research and development at universities and industry.

Thank you very much. I would be delighted to answer your questions.

Mrs. LLOYD. Thank you, Dr. Russell.
Mr. Crandall, please proceed.

STATEMENT OF GEOFFREY C. CRANDALL, DIRECTOR, INDUSTRIAL, COMMERCIAL AND INSTITUTIONAL DIVISION, MICHIGAN PUBLIC SERVICE COMMISSION, ON BEHALF OF THE NATIONAL ASSOCIATION OF REGULATORY UTILITY COMMISSIONERS, WASHINGTON, DC

Mr. CRANDALL. Thank you. Good morning, Madam Chairman, and Members of the Subcommittee. My name is Geoffrey C. Crandall and I'm here on behalf of the National Association of Regulatory Utility Commissioners.

The job that we have, which is different, I think, from the other witnesses this morning, is the job of ensuring that consumers have reliable, high-quality, low-cost energy utility service. That's our job. We're, in effect, the practitioners of this. We are the utility regulators. We're at the point at which the rubber meets the road in some of these issues. We're very pleased to have the invitation today to be here.

Now, the experiences that we have with the issues we're talking about this morning lead us to believe that the public good is best served when utilities pursue a broad and diverse set of options. The utilities have the obligation to serve their customers and have to respond to whatever demands customers place on them. We're also concerned with reduced rates and enhanced national competitiveness. That's why we're here today, because we believe this bill will help us do the things that we need to do better. We strongly support this bill.

The one aspect of this commercialization is, in my judgment, a very serious bottleneck in our pursuit of energy efficiency, in a nation to have a secure and competitive energy future.

I guess the reason that we're here today, and the reason we feel there is a key issue on the table for us, is simply that we, day in and day out, deal with multibillion dollar rate applications. We do now look at a 20-year planning horizon. In the new efforts that have been put forth around the country, we have an integrated resource planning emphasis, a least-cost planning emphasis, and we are looking at all kinds of options that are out there, not just traditional supply options.

What we're seeing is rather phenomenal. We're seeing, with 1960's and 1970's technology, a tremendous opportunity for conservation and energy efficiency. In fact, in some States we're seeing as much as 50 percent of the future need for energy would be provided by energy efficiency conservation measures. This is commonplace. We're seeing this in Michigan, we're seeing this in other jurisdictions. So the fact that we have 1960's and 1970's technology now that is off-the-shelf and is proven, and that can respond to our future needs in that way, to us is very significant.

The ability to analyze options in the future, make "apples-to-apples" comparisons, and look at supply options and demand-side options in the same way is a vital effort, and that's why there is so much interest nationally with PUC's in this area of integrated resource planning.

We also are concerned with the environmental impact. You've heard a lot about this today and I don't need to repeat this—I don't want to bore you. It is a very serious concern in the regulatory community. The external effects, the effect on the employment effect in our various jurisdictions, the effect on the economics of our State, the fact that billions of dollars flow from without our States to other countries for importing energy needs so we can make electricity, we can provide our homes with gas. This is a State problem. This is a national problem.

The reliability of supply. We have to have reliable, solid supply sources. The diversity of supply. We think it makes a lot of sense to minimize your risk by having a number of ways to get to supply. Social equity problems. And these are things that we're looking at, as you are.

A recent development that I would like to share with you is in or State of Michigan, we reacted to a Federal initiative, the Residential Energy Audit Program, and that was sparked in 1981 by the National Energy Act. And we took quite a bit of effort to analyze this program to see what effect it has. An order came out just a couple of days ago, after several years of research, which the Commission found that this program had a positive economic benefit to the State. In fact, one of the witnesses explicitly quantified a $300 million net economic benefit to the State of Michigan alone, and we're the eighth largest State, I believe, in the country. So this type of a program, Federal involvement with State flexibility and utility cooperation, certainly I think has a lot of promise and we're certainly interested in that.

The energy-efficiency opportunities that I think this bill would certainly advance has two benefits. Number one, we're finding that energy efficiency options, conservation options, are economically viable. They're much cheaper than other options. And secondly, they do result in a cleaner provision of energy services for the customers.

So what do we do next? What happens next? How could this bill enhance the efforts that we're trying to put forward? We believe that a Federal, State and utility joint partnership is doable and could enhance the jobs we're both trying to do. Least-cost planning I believe is vital. It gives the States some powerful ways to have flexibility and meet our future needs, and I think a joint partnership will help the States do much of what we're going to do anyway, but we can't do it all. There's no question about that. I don't believe that the Federal agencies, even though they're trying, can do it all. I think there needs to be a partnership with the State, the Federal, and the industry, to move forward to promote commercialization of end use efficiencies and promote conservation in the renewables is very important.

I think through this cooperative arrangement we have a situation where the whole is, in fact, greater than the sum of the parts. We have a synergism. We have an ability to do greater things.

So we would like to work with the Federal agencies to do our job better and to help integrate these new technologies, because we are now getting into a position, as State regulatory commissions, where we can use new end use technologies, we can integrate it with look-

ing down the road at ways to meet future supply, and we stand ready to do that.

Thank you very much for the opportunity today to address you.

[The prepared statement of Mr. Crandall follows:]

BEFORE THE
UNITED STATES HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

TESTIMONY OF

GEOFFREY C. CRANDALL
MICHIGAN PUBLIC SERVICE COMMISSION

ON BEHALF OF THE

NATIONAL ASSOCIATION OF REGULATORY UTILITY COMMISSIONERS
1102 INTERSTATE COMMERCE COMMISSION BUILDING
CONSTITUTION AVENUE AND TWELFTH STREET, N.W.
POST OFFICE BOX 684, WASHINGTON, D.C. 20044-0684
TELEPHONE (202) 898-2200

ON

H.R. 4226
RENEWABLE ENERGY AND ENERGY CONSERVATION

June 30, 1988

TESTIMONY OF
GEOFFREY C. CRANDALL
MICHIGAN PUBLIC SERVICE COMMISSION

ON BEHALF OF THE

NATIONAL ASSOCIATION OF REGULATORY UTILITY COMMISSIONERS

Madam Chairman and Members of the Subcommittee:

My name is Geoffrey C. Crandall. I am the Director of the Industrial, Commercial and Institutional Division within the Michigan Public Service Commission and I serve as the Chair of the Staff Subcommittee of the Committee on Energy Conservation of the National Association of Regulatory Utility Commissioners (NARUC), on whose behalf I appear today.

The NARUC is a quasi-governmental, non-profit Association founded in 1889. Our members are the state commissions responsible for the regulation of our nation's utilities and carriers. This fall, NARUC will mark it's first full century of commitment to public service. During these many years, we have ardently pursued our responsibility to ensure that America's consumers are reliably provided with the highest quality, lowest cost utility service possible, and we will endeavor to continue in this tradition.

As a result of our extensive involvement with these issues, we are convinced that the public interest is best served when utilities pursue a broad and diversified set of options to satisfy their customers needs. Today, we are speaking about

energy needs, and it is with this in mind that I appear before you in support of H.R. 4226, a bill to promote the development and commercialization of renewable energy and energy conservation.

NARUC's support for the bill is based on a **Resolution Supporting the Adoption by State and Federal Regulatory Commissions of a Policy Mandating Electric and Gas Utilities to Develop and Submit for Approval Least-Cost Resource Plans**, adopted November 28, 1984; a **Resolution Supporting the Adoption of National Energy Goals**, also adopted in 1984; and a **Resolution in Support of Federal Research on Energy Conservation** adopted November 19, 1986. Copies of these Resolutions are attached hereto.

We are extremely pleased that this bill focusses on the commercialization of renewable energy and energy efficiency technologies. Commercialization is a serious bottleneck in our pursuit of energy efficiency, and if we are to ensure this nation a secure and competitive energy future the commercialization and market acceptance of such new technologies is essential.

This bill would provide greatly needed multiple-year funding to advance commercialization and R&D in several important energy conservation and renewable resource areas. This continued commitment is no small matter. Long lead-times are an

inextricable part of the equation in securing future energy needs. This is true for electric generation and transmission options as well as options available on the customer side of the meter, i.e. the demand side. The research, development and commercialization of energy conservation and renewable resource options must be a long term commitment, not a vacillating target that "bobs and weaves" with each year's budget pressures.

We are in a business that places high value on stability and continued commitment to improvement. This is especially crucial because the development and adoption of end-use technologies involves high capital-intensive stakes. We have seen and experienced the potential for financial catastrophe associated with failed electric generation construction or supporting unneeded, yet operational plants.

The federal government's funding in the R&D area of end-use technology applications and energy conservation programs has proven to be a great success. Several federal initiatives have already resulted in millions of consumers minimizing their utility bills and have sparked the development of many new energy-saving technologies by U.S. industries, many of which will provide marketing opportunities abroad.

Stimulated initially by the oil embargo era, energy efficiency has proven to be one of the most effective,

economical, and fastest growing options for meeting future energy needs. A case in point is the federally initiated Residential Conservation Services (RCS) program emanating from the National Energy Act of 1978, which has been operating in Michigan since 1981. During that time over one-quarter of all homes in Michigan -- over 900,000 customers --have participated in the program. For several years state and utility researchers intensely analyzed the results and effects of the program. Those results were offered in an evidentiary proceeding before the Michigan Public Service Commission in a review of the costs and benefits of these programs.

Two days ago, on June 28, 1988 the Michigan Public Service Commission ruled that the RCS programs "are cost-beneficial and have had a positive economic benefit to the state." In that proceeding witnesses quantified the net economic effect on Michigan's economy, based on the first five years of the RCS program, to be over $300,000,000! (projected through 1997). This example demonstrates that federal involvement, coupled with state flexibility, can be extremely worthwhile, and that a continued commitment to energy efficiency and conservation is most certainly warranted.

The NARUC Committee on Energy Conservation has strongly supported the Department Of Energy's Least-Cost Utility Planning (LCUP) Initiative. This innovative "technical transfer" program

assists utilities and regulators in developing new institutional frameworks for incorporating a broad array of supply and demand options in the utility planning process. Continued funding of the DOE LCUP program is of special concern to NARUC because the program helps to bring new, economically attractive energy conservation technologies into millions of homes, businesses and public buildings across the country -- and it is the only federal program which addresses the utility's role in conservation. Since they are the most capital intensive industry in America, incremental efficiency improvements can have profound effects.

. The Michigan, Wisconsin, Pennsylvania and District of Columbia the Public Service Commissions have recently ordered their jurisdictional electric and gas. utilities to initiate or continue aggressive energy conservation programs. And much of the energy savings already accomplished or anticipated through these programs is possible because of the pioneering research conducted by organizations such as the Lawrence Berkeley Laboratory, through funding provided by DOE.

Our interest in H.R. 4226 is due in part to the recognition that State utility regulation is now undergoing substantial change, as are the industries we regulate. One of the most important realizations among the regulatory community is our growing awareness that the business of supplying utility services

has become far more complicated than the simple production and sale of a commodity.

For example, rather than simply selling gas or electricity, many utilities now supply a range of energy services, oftentimes including conservation services designed to reduce the utility's energy sales. Of course the problem is how to make it worth the utility's while to reduce its sales. We think we can do it -- by providing a regulatory structure in which demand- and supply-side alternatives are given equal weight, and in which the utility is provided an economic incentive to invest in what will be the least expensive alternative for the consumer. Hence the term "least-cost planning."

We have also become increasingly aware that we must now consider the environmental consequences of utility services, social equities, and the effects of utility planning and operation on our economic competitiveness as a nation. A one-half cent difference in price paid for a killowatthour of electricity by a Michigan steel plant, for instance, might mean the difference between the company being able to compete in a world market and having to shut its doors. And its not just the company's shareholders who suffer.

We are therefore faced with planning decisions whose complexities are immense and whose cost implications are

profound. After fifty years of steady increase in demand and consistent decrease in price, the electric utility industry and its ratepayers woke up to a relatively sudden shock throughout the 70s and early 80s when the demand curve flattened, plant costs skyrocketed, and the nuclear option became a matter of intense public controversy.

At the same time we became aware of utility-related environmental issues such as acid rain, PCB disposal, and the seemingly unanswerable debate over what to do with spent nuclear fuel. And now, just when the nuclear option seems to be a minuscule one at best, at least in the near term, we are presented with growing scientific evidence that carbon dioxide emissions from the combustion of fossil fuels is likely to cause global warming and profound ecological change.

In response to this scenario, regulators are attempting to view their responsibilities in more of what one might call a "holistic" context. And we are realizing that, just as there are more "costs", or "externalities", involved with utility services than meet the eye, there are opportunities available through the regulatory structure which were not historically part of the ratemaking process, i.e. opportunities to affect social, environmental and broad economic considerations which are not part of traditional regulation, which merely dealt with pricing electrons or molecules of gas.

A considerable number of state regulatory bodies are exploring the possibilities of using utility regulation as a means of inducing the efficient use of energy with the most benign external consequences. These efforts are based on a growing amount of evidence that a vast remaining potential for energy efficiency exists and that the utility structure is an efficient and appropriate means through which to develop such potential. According a national survey completed in June 1987, thirty seven states have taken substantive actions in this area through least-cost utility planning.

The concept of energy efficiency is clearly a common denominator among many of the serious challenges now facing us. With respect to national energy policy, the efficient use of energy is a major hedge against OPEC dominance. With respect to international competitiveness, the relationship of energy use per unit of GNP is of critical importance to the survival of our nation as a manufacturer. With respect to reducing acid rain producing emissions, energy efficiency and conservation may be a key cost effective strategy.

But it is with respect to what is know as the "greenhouse effect" that the need for energy efficiency and conservation becomes acute. It is becoming increasingly clear that we must reduce the amount of carbon dioxide emissions we produce by

burning fossil fuels if we are to avoid global warming. There are only two ways to do it: we can either use non-fossil fuels, or we can reduce our demand for energy. Since the only major non-fossil fuel option now available is nuclear -- and it is unlikely that we will see a resurgence of new nuclear construction anytime soon, at least not during the next building cycle -- energy efficiency and conservation appear to be the only near-term answer.

As the utility business becomes more complicated, the role of the both federal and state governments in meeting the challenges it presents will be increasingly important. Clearly, there is a necessary role for a strong federal presence in matters of interstate commerce, in supplying R&D and technical support, and in promoting energy security. States have taken the initiative in many areas, but we can't do it alone. Least-cost planning needs to be supplemented by a flow of new technologies and techniques that will make demand-side management truly able to compete head-to-head with new sources of supply. And we can't implement such planning techniques on a national scale without federal support. We will continue to monitor the promising federal R&D projects which are currently underway, and with the help of the DOE Least Cost Utility Planning funds we will endeavor to quickly translate new energy savings opportunities into lower energy costs for all consumers.

In conclusion, energy efficiency and conservation opportunities could help in cost-effectively meeting our nation's future energy needs, reducing our dependence on foreign energy suppliers, improving U.S. international competitiveness, improving environmental quality, and helping reduce the burden on those with low and fixed incomes.

Regulators can help supply regulatory tools to advance these goals. Maine, for example, has adopted a competitive bidding procurement system for new electric supply which allows energy savings to compete directly with new sources of supply. The program is extremely fruitful, both in terms of being cost-effective and in stimulating opportunities for conservation which, under traditional schemes, might never have been achieved. Similarly, the Federal Energy Regulatory Commission could, if it so chose, use its pending electricity rulemakings to revise its regulatory structure to achieve such a result.

But there are many other areas in which these goals can be pursued. One is in the nation's housing finance structure. If lenders can be persuaded to consider a home's efficiency in their mortgage practices, the value of a house will reflect its energy-related operating costs, giving homeowners, landlords and builders increased incentive to invest in efficiency improvements, again helping to remove an important bottleneck toward commercialization. Recent NARUC correspondence to the

Department of Housing and Urban Development (HUD) on this subject is attached hereto.

NARUC therefore urges the Congress to adopt H.R. 4226. It is yet one more stone in helping to build a strong foundation for a truly energy efficient economy, which is going to become increasingly necessary if we are to keep pace with the Japanese and keep OPEC at bay. We therefore urge the timely enactment of H.R. 4226 and will provide this Committee with whatever ongoing assistance it requires in this important debate.

I sincerely appreciate the opportunity to testify.

Thank you.

# # #

Convention Resolution No. 7

Resolution Supporting Adoption by State and Federal Regulatory Commissions of a Policy Mandating Electric and Gas Utilities to Develop and Submit for Approval Least-Cost Resource Plans

WHEREAS, It is imperative that the Nation exert more control over its energy future and acknowledge its inherent uncertainities; and

WHEREAS, It is necessary that demand and supply planning be fully integrated to ensure that resources are used prudently and that our energy needs are met at the least possible cost; and

WHEREAS, Energy conserved is a resource and should be subjected to the same need and cost-effectiveness standards as other resources; and

WHEREAS, Conservation can reduce growth in energy demand and thus reduce the need for the construction of new electric facilities; and

WHEREAS, Conservation should be viewed by utilities as an alternative to new supply options; and

WHEREAS, Implementation of this policy will provide the ability to select resources based on the most important factors: need, cost reliability and environmental considerations; now, therefore, be it

RESOLVED, By the National Association of Regulatory Utility Commissioners, assembed in its Ninety-sixth Annual Convention in Los Angeles, California, that State and Federal regulatory commissions should adopt a policy which bases the determination of need for new facilities on the development of a least cost supply plan which evaluates and incorporates all cost effective conservation, load management and alternate energy sources in the least cost supply plan; and be it further

RESOLVED, That least cost resource plans should include consideration of the following: (1) conservation; (2) renewable resources; (3) generating resources using waste heat or generating resources of high fuel conservation efficiency; and (4) all other resources.

Sponsored by the Ad Hoc Committee on Energy Conservation
Reported NARUC Bulletin No. 2-1985, page 16
Adopted November 28, 1984

Convention Resolution No. 5

Resolution Supporting the Adoption of National Energy Goals

WHEREAS, There are national imperatives which require renewed vigor in the development and implementation of national energy policy; and

WHEREAS, The Nation continues to be dependent upon petroleum and other non-renewable resources as energy sources; and

WHEREAS, Existing national and international energy policies and conditions do not preclude the recurrence of serious problems arising from this dependence; and

WHEREAS, The increase in energy prices has a major adverse impact on the Nation's citizens and its economy; and

WHEREAS, Conventional sources of energy are subject to constraints involving supply, transportation, cost, environmental, health and safety considerations; and

WHEREAS, The Nation must devise strategies by which to address these problems including, but not limited to strategies to assure adequate, efficient, reliable energy supply and to avoid unnecessary and wasteful consumption; and

WHEREAS, Cost effective energy conservation measures can address such issues appropriately; now, therefore, be it

RESOLVED, That the National Association of Regulatory Utility Commissioners, assembled in its Ninety-sixth Annual Convention in Los Angeles, California, adopts the following goals and urges the government of the United States to find it in the interest of the nation to:

I. Assure adequate and reliable energy supply by using resources in the most efficient manner, by replacing energy resources vulnerable to interruption due to circumstances beyond the nation's control with those less vulnerable, and by encouraging the development and utilization of renewable resources;

II. Define conservation in terms of both avoidance of unnecessary and wasteful consumption and in terms of economic efficiency;

III. Promote conservation by encouraging consultative participation of states, local governments, consumers, energy companies, and the public at large in developing, implementing and updating plans and programs related to energy resource conservation and development;

IV. Improve utility conservation programs by raising consumer awareness to the benefits of conservation, by increasing consumer participation and by requiring utilities to develop programs to achieve implementation of audit recommendations;

V. Encourage development of least cost system plans for major gas and electric utilities in order to meet energy needs over the coming decades, which plans shall include the following: (1) conservation, (2) renewable resources, (3) use of waste heat or high fuel conversion efficiency and (4) all other resources;

VI. Concentrate additional federal efforts on strengthening the Department of Energy's ability to gather data, provide coordination and provide assistance to states and the public; on establishing national appliance efficiency standards; on requiring increased thermal efficiency in buildings; and on establishing energy efficiency in transportation; and

VII. Provide for the essential energy needs of the disadvantaged by providing utility incentives for the development of conservation and audit services, by providing increased permanent weatherization services for low income households, and by eliminating financial barriers to conservation improvements for the needy through loan or grant programs.

Sponsored by the Ad Hoc Committee on Energy Conservation
Reported NARUC Bulletin No. 2-1985, pages 14-15
Adopted November 28, 1984

Resolution in Support of Federal Research on Energy Conservation

WHEREAS, An energy policy that provides a balanced reliance on supplies and demand is essential to the Nation's future well being and security; and

WHEREAS, The current worldwide oil surplus and resulting lower oil prices are providing a misleading signal that the energy crisis has passed; and

WHEREAS, The ability of the Nation to adjust to future energy supply constraints will depend on the development of new energy efficient products and technologies; and

WHEREAS, The gestation period between the initiation of research and the introduction of new products and technologies into the marketplace is as long as 20 years; and

WHEREAS, A vigorous conservation research program must be given a high priority now if the Nation is to have the new technologies and products needed when energy supplies become increasingly constrained; and

WHEREAS, Increased energy efficiency is cost effective and will help achieve environmental goals including a reduction in acid rain, the "greenhouse effect" and oxidation damage to trees and crops; and

WHEREAS, The building industry, unlike the transportation and industrial industries, is not dominated by large firms which have the motivation and resources to invest in reducing their energy expenditures; and

WHEREAS, Building energy efficiency is of particular interest to public service commissioners; now, therefore, be it

RESOLVED, That the National Association of Regulatory Utility Commissioners (NARUC), assembled in its Ninety-eighth Annual Convention in Phoenix, Arizona, requests Congress and the Department of Energy to increase the funding of conservation research, particularly for the building sector, so that a balance will be achieved in our Nation's energy programs.

Sponsored by the Committee on Energy Conservation
Adopted November 19, 1986
Reported in **NARUC Bulletin** No. 48-1986, p. 6

National Association of Regulatory Utility Commissioners

Incorporated

BRUCE HAGEN, *President*
North Dakota Public Service Commission
State Capitol
Bismarck, North Dakota 58505

HENRY G. YONCE, *First Vice President*
South Carolina Public Service Commission
111 Doctors Circle, Post Office Box 11649
Columbia, South Carolina 29211

SHARON L. NELSON, *Second Vice President*
Washington Utilities and Transportation Commission
Chandler Plaza Building
1300 South Evergreen Park Drive, S.W.
Olympia, Washington 98504

1102 Interstate Commerce Commission Building
Constitution Avenue and Twelfth Street, N.W.
Post Office Box 684, Washington, D.C. 20044-0684

Telephone: 202-898-2200

PAUL RODGERS
Administrative Director
General Counsel

GAILE ARGIRO
Treasurer

June 28, 1988

HUD RULES DOCKET
JUN 28 3 17 PM '88
REC'D

Rules Docket Clerk
Office of the General Counsel
Room 10276
Department of Housing and Urban Development
451 Seventh Street, S.W.
Washington, D.C. 20410

DELIVERY BY HAND

Re: Docket No. R-88-1372; FR-2333
Deregulation of Loan Origination
Fee and Mortgagor Income Requirements

Dear Sir/Madam:

On behalf of the Committee on Energy Conservation of the National Association of Regulatory Utility Commissioners (NARUC), I wish to express strong opposition to the provision[1] in the above proposed rule which contemplates removing consideration of heat and utility costs in determining a mortgagor's eligibility for an HUD-insured loan.

Our opposition to this provision is based on the fact that removing consideration of heat and utility costs would act to discourage energy efficiency in housing. Rather than discouraging energy efficiency, it would be more appropriate, both as a matter of national energy policy and in terms of basic economics, to use the Department's mortgage rules as an incentive for building energy efficiency into new homes and for improving the efficiency of existing homes.

The NARUC is a quasi-governmental, non-profit Association comprised of the State commissions responsible for the regulation of our nation's energy utilities. Through our experience in this

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[1] 53 Fed. Reg. 15409, April 29, 1988

area we have come to realize that there exists within our utility infrastructure a vast potential for energy savings, and that our regulatory structures can be used to help capture this potential. One means of doing this, for example, is by including in the utility planning process analysis and implementation of demand-side alternatives to traditional supply-side strategies. In other words, if a utility identifies the need for new capacity, it should first analyze whether energy savings can be obtained at a comparable, or lesser cost -- hence the term "least-cost planning."

Least-cost planning, however, will be much more efficient if complemented by conservation programs in other areas, such as appliance efficiency standards. Such standards are necessary because, while an educated consumer may buy an appliance based on life-cycle cost, a developer or landlord, who is not responsible for the project's utility bills, is given an incentive to buy only whatever has the cheapest price tag, which is usually the most inefficient product.

Similarly, the value of a home should reflect its energy efficiency, especially since energy bills are a homeowner's largest non-mortgage operating cost. A home with a higher energy rating will necessarily have lower operating (i.e. life-cycle) costs, and is therefore a "safer" investment with a higher potential resale value. This, we feel, should not only be reflected, but encouraged through the policies of the nation's lenders. Failure to reflect such criteria is, in fact, a strong disincentive to energy efficiency.

We therefore oppose removing the consideration of heat and utility costs from FHA underwriting practices, and support the positions taken by the Alliance to Save Energy and the Northwest Power Planning Council in their comments in this docket.

Respectfully,

Steve Wiel J.E.

Steve Wiel
Commissioner,
Nevada Public Service
Commission

Chair,
NARUC Committee on Energy
Conservation

Mrs. LLOYD. Thank you, gentlemen, for being here and your very excellent testimony.

Dr. Russell, I'll start with you. I'd like you to elaborate a little bit further on your 60/40 split for university/industry to in-house research.

Dr. RUSSELL. I think that you'll find, if you look at the DOE plan, that the goals, the performance goals that have to be met have been largely met by the university and industrial subcontractors and the Solar Energy Research Institute. And the danger, when we have a Government-run laboratory, is that in times of budget cutting that they keep the money in-house and don't send any of it outside. And it's important that we maintain some kind of watchdog arrangement, and the only entity that I know that can do this successfully is Congress itself. And so my recommendation is that they set aside a certain amount of money and mandate it that it go outside.

I think in the long run this is healthy for the Solar Energy Research Institute, because it gives them a wider constituency and the research effort is spread about and generally more effective. Since they do the program management, then they bask in the reflected glories of what other people produce also.

Mrs. LLOYD. How would you rate SERI as a program manager in photovoltaics in regard to in-house versus outside research?

Dr. RUSSELL. I think they do a very good job on program management. I think that they are somewhat weak in integrating the program management with the in-house research.

Mrs. LLOYD. I really appreciate your suggestion of phased cooperative venture programs in which the utilities provide their fair share of the demonstration funding. But I'd like for you to give us a little bit more information on the sort of incentives that should be provided to encourage the utility participation. As you know, they've been rather hesitant at times on some of these programs.

Dr. RUSSELL. Well, I think that Congressman Fawell made an issue earlier when he said there are certain costs that we can't put on a dollar and cents basis. We have to start paying attention to some of these costs. The environmental cost is a very real one and has major implications. So I think somehow we need some sort of legislative action that will convince utilities that they have a role to play in keeping the environment safe.

Secondly, there's an educational issue here to convince utilities that they should use new technology.

Mrs. LLOYD. Well, you know, in my interaction with utilities, I'm always reminded they have to answer to the ratepayers. As you know, TVA has had to make some big decisions and cutting back about $300 million out of their budget this year. It's been rather painful for my District. But they are rather unique in how they can make their investments because of their obligation to ratepayers and being competitive. It's not always that easy.

Dr. RUSSELL. No, I think it's a very tricky social-political problem that has a relatively minor technology component. I think that the ratepayers and the public service commissions have to be convinced sometimes that there's an advantage.

Mrs. LLOYD. It's a very fine line for utilities.

Dr. RUSSELL. Yes, it's a very difficult task for utilities to face this.

Mrs. LLOYD. Thank you.

Mr. Crandall, how would you propose to facilitate technology transfer of energy-saving technologies from the lab to the public?

Mr. CRANDALL. Well, one way, I think, that we've seen very effectively was DOE's project, the Least-Cost Utility Planning Project. That is an excellent example of having the Federal Government be a major catalyst in having the latest technical information shared with all the public service commissions. I mean, this is an excellent example of what I believe—they've been able to develop data bases, arrange, in cooperation with some States, a computerized system where they're sharing information every day, and it's a tremendous example of this. I believe in the budget there is provision for that, so that would be one example that I could cite offhand.

Mrs. LLOYD. Thank you very much.

Mr. Morrison?

Mr. MORRISON. Mr. Crandall, I wanted to ask you, since you are sort of where the rubber meets the road, on energy and its use by our citizens, the most effective conservation I've seen in the Northwest, where we have reasonably low-cost electricity rates, has come as the cost has gone up. But could you, through your work in your organization, compare for us that conservation that comes just because it's costing you more with programs that have done the energy audit and provided some sort of economic incentive, other than just in the price of what power you might save?

Mr. CRANDALL. Well, I think we're finding now in the East Coast and West Coast, in various spots, Wisconsin, I think, and Michigan, through this broadening process. The regulatory framework that we're trying to achieve is sort of a broadening of the options, reliable options. We have to have reliable energy provided, certainly.

What we're finding is that the nontraditional supply sources, cogeneration, biomass fuel projects and so forth, where those things are really considered on an equal basis, they are very economically viable. I think you can get to some new supply options with the broadening of the process. I think also certainly conservation can be promoted through rate structures, by having slightly inverted rates and other rate signals that you can give to the customers.

Mr. MORRISON. Can you do that in most States? Of course, you represent, in essence, regulatory processes.

Mr. CRANDALL. Yes.

Mr. MORRISON. Can you build in the rate base incentives to encourage people not to buy your product?

Mr. CRANDALL. Yeah, I think you can, certainly you can, if you are looking at the on-peak pricing versus off-peak. I mean, where you have in the Northwest, where you have a peak, a "needle peak" we call it, where you have a tremendous surge of demand at a certain time of day, the extent we can shift those people off that power demand to another time, and we can do that through interruptable rate options and demand management programs, which we're doing. Then we cannot have to purchase outside power and we can use the more inexpensive sources of power generation. So yes, you can do that through rate signals and through pricing. And

many of us are doing that. That's one of the first things, really, that you go at.

Mr. MORRISON. We get the impression here that utilities are—having gone through nuclear shock, if you will—laying back and really not investing now in anything as far as new power sources are concerned.

Is that basically true, or are you just waiting for the new generation of nuclear reactors, or for the public interest to change, as far as nuclear is concerned, or are you really counting on a number of these projects that Dr. Russell and Dr. Hubbard and others are going to bring to us, that they will provide new sources of energy?

Mr. CRANDALL. Well, obviously the nuclear option is in serious trouble at this point. How serious, we don't know, but at this point there is a lot of interest in the nontraditional sources—cogeneration and demand-side management. And there are a number of utilities spending a lot of money to pursue what they believe is reliable and trustworthy and solid energy efficiency options. So utilities, of course, have to look, you know, twenty years down the road. They have a long planning horizon and they have to deal with that. And they're now trying not to make huge investments certainly in these kinds of plants and we find some true and sincere interest in exploring energy efficiency and demand-side energy technologies. And that's encouraging to us.

Mr. MORRISON. So you could squeeze some more money out of utilities to come part way toward the cooperation that Dr. Russell and Dr. Hubbard need?

Mr. CRANDALL. I think that's definitely a possibility. I'm encouraged by some of the efforts of EPRI and EEI to look at a broader set of options, too. It's possible.

Mr. MORRISON. Good. Thank you.

Mrs. LLOYD. Thank you, Mr. Morrison.

You gentlemen provided very excellent testimony and certainly I want to thank all of our witnesses. It certainly will help us to give further consideration to H.R. 4226. To Nancy Jeffery and Kitty Rising, I want to thank you for your excellent help, and for our recorder as well. It's been a very good hearing.

If there's no further business, the Subcommittee stands adjourned.

[Whereupon, at 12 noon, the Subcommittee was adjourned.]

APPENDIX

Additional Statements for the Record

STATEMENT OF

DONNA R. FITZPATRICK

ASSISTANT SECRETARY
CONSERVATION AND RENEWABLE ENERGY

U.S. DEPARTMENT OF ENERGY

BEFORE THE

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES

June 30, 1988

Mr. Chairman and Distinguished Members of the Committee:

It is a pleasure to be here with you today to discuss the significant role of renewable energy and conservation in our energy future.

Today, our energy situation is greatly improved over that of the 1970s. The United States uses no more energy and less oil than we did in 1973, although the population is growing and the Nation steadily continues to turn out more in products and services, more than 30 percent more per year than in 1973. In 1986, the U.S. used 25 percent less energy than it took in 1973 to produce a given level of goods and services, with over half of this improvement coming since 1980. Clearly, energy conservation has been an indispensable and pivotal element in today's energy stability and security. Had it not been for the Nation's wise and impressive adoption of economically justified conservation technology and changes in energy user behavior the United States would now probably require 104 quads rather than 75 quads of energy each year. Of the 29 quads, about half were due to increased efficiency in the form of technology improvements. The rest was due to shifts in the mix of industrial products and changes in consumer behavior. Those savings represent more energy than we get from any other domestic resource.

Renewable energy has grown to supply 9 percent of our total energy needs and represents one of the fastest growing energy supply sources. The combination of solar, wind, geothermal, hydropower, and biomass energy represents an extremely large resource base that, over the long term, could become a major source of energy supply. The majority of the renewable energy used in the

world now comes from conventional large hydroelectric plants and wood fuel--both of which have only slight future growth potential. There are other types of renewable energy that might grow almost explosively in the early part of the next century, but these are the ones based on much higher technology.

While the energy situation is improved, it is not a reason for complacency. It is clear that a successful national energy policy must encourage both increased efficiency and supplies of conventional and alternative energy. Conservation will never reduce energy demand to zero, it will only slow its growth. We must in the short term replace depleted supplies and eventually substitute renewable or abundant fuels for petroleum. In addition, energy efficiency improves the overall efficiency of our ecomomy, especially in energy-intensive basic industries.

The Department of Energy's strategies to help the renewable energy potential to emerge and energy efficiency to improve include continued research, active international energy collaboration, and a continued Federal leadership role. The Department focuses its research and development activities on selected high-risk and high-payoff projects. It is willing to undertake precommercial stages of "higher risk" projects that show potential for large long-term benefits, but which would not be cost-effective for private organizations to pursue alone. Many are carried out by private companies and institutions operating under cost-shared contracts or cooperative agreements with the Department. These activities complement industry efforts and do not displace them.

Examples of the results of DOE cooperation with industry include twenty-two technologies developed with Federal R&D support and cost-shared by private industry which are already saving U.S. industry and its customers energy expenditures that were valued at $150 million in 1986. Other DOE program contributions are also significant. For example, today's geothermal industry contributes more than 2000 MW to the nation's energy supply; small-scale hydropower plants represent another almost 7000 MW of capacity; and there are nearly 1500 MW of installed wind energy capacity in the U.S. Even the less mature technologies such as photovoltaics and solar thermal are making growing contributions. For example, some 40 utilities now have more than 70 photovoltaics projects in all parts of the country testing both central station and distributed applications. Enormous opportunities exist for future energy improvements. The Administration's aggressive response to the implications of high temperature superconductivity is an example of where the government should act and what it can do in cooperation with the private sector and utilizing the tremendous resources in our national laboratories. It also exemplifies the need for flexibility in directing funds to fast moving and high potential areas.

Over the last several years, my office has developed a very effective strategy for program planning and project selection which has received peer review or input from numerous members of the research community, including the National Academies of Science and Engineering, the Energy Research Advisory Board, and industry. The results of this effort are the multi-year plans for the Office of Energy Conservation and the Office of Renewable Energy. These multiyear research plans provide a workable, peer-reviewed approach to prioritizing and selecting projects that best support the national interest. Copies of these plans were sent to the subcommittee in January for your review and

consideration. We would welcome any advice or comments that you may have on the plans.

On an across the board basis, U.S. industry and the university and laboratory research base are recognized as world leaders in conservation and renewable energy technologies. Research sponsored by the Department is aimed at maintaining the U.S. on the cutting edge of technology and is the basis for future improvements in competitiveness in the mid-and long-terms. Predictible and well-targeted support for both public and private research is necessary to maintain our position in the international marketplace.

The Department's activities undertaken in support of the Committee on Renewable Energy Commerce and Trade (CORECT) are an example our involvement in improving the renewable energy industry's international trade opportunities. This interagency committee, established by DOE in response to the Renewable Energy Industry Development Act of 1983 (P.L. 98-370), has grown to play an aggressive catalytic and supportive role in promoting and assisting U.S. developed renewable energy technology within an increasingly competitive international marketplace. CORECT is focusing on providing international decision-makers (in donor agencies, banks, and host countries) with the information needed to include renewables in their investment analyses, and on providing U.S. industry with information and improved access to financing of export opportunities. CORECT and its subcommittees are working with industry to identify U.S. and international financial institutions and to educate decision-makers in these institutions about competitive applications for renewable energy. In addition to DOE, the Department of Commerce and the Agency for International Development play significant roles in CORECT activities. Through CORECT's numerous activities, which are detailed in the

attached CORECT report, the renewable energy industry has realized new foreign market opportunities. CORECT is committed to continuing these and other efforts to realize the large foreign market potential that has yet to be tapped.

Clearly, the Department believes that the potential for energy conservation and renewable energy has by no means been exhausted. In fact, the creativity and initiative of U.S. scientists, inventors, entrepreneurs, and industry continue to prove that human ingenuity, scientific opportunity, and market incentives are working. This country can save another 10 to 25 quads of energy annually by the year 2000 if existing cost-effective technologies and those anticipated from future R&D are applied fully to improve energy efficiency . By the year 2005 renewable energy can grow from 9 percent to 13 percent of domestic energy supply.

Ultimately, success in energy efficiency and supply will depend literally on actions by tens of millions of individuals and organization, whose actions are inherently decentralized. Small actions by a multitude of people result in large cumulative effects.

H.R. 4226

There are four features of the proposed Renewable Energy and Energy Conservation Commercialization and Development Act (H.R. 4226) on which we would like to comment: programmatic authorizations for conservation and renewables; enhancing the international development programs; requiring a more rigid process for developing technical goals and objectives; and requiring commercial demonstration projects of renewable energy technologies.

With respect to program authorizations, we very much appreciate the commitment of this committee to conservation and renewable energy. However, we are concerned that substantially higher levels of authorization can create false expectations on the part of program participants and divert attention from reaching a consensus on the technical priorities that can best be included in realistic appropriation levels. Our recommendations with regard to affordable levels of investment for research in these areas have been articulated through the annual budget process.

Another provision of the bill calls for enhancing international development programs. We are proud of the accomplishments to date in our international program. We believe substantial progress has been made in facilitating cooperation among public and private development agencies and between those agencies and the private sector. We believe we have sufficient legislative authority to continue this activity in the necessary direction. It is our view that most of the success to date has resulted from development of effective institutional relationships rather than from program outlays. The required level of funding must be reviewed by us on an annual basis within the context of overall funds availability, our basic priorities for meeting research needs, and the status of international program activities.

The Department agrees that cost and technical goals to guide conservation and renewable energy research are necessary. Each of these programs has developed such goals in cooperation with industry and published them in multiyear plans which were sent to the Subcommittee in January for review and comment. The multi-year plans are updated when warranted, based on the economics of competing technologies, research advances, available funding levels, and

various other factors. They are a valuable tool for involving others in the planning process. We are unaware of any basic flaws in our current approach to research planning which would warrant legislative remedy.

Another feature of the legislation proposes the establishment of commercial demonstration projects. As discussed on many occasions, we believe our investment should be focused on a broadbased research program, one that provides opportunity for advancing technologies while recognizing the innovative capabilities of the private sector. Diverting funds to commercial demonstrations retards the pace of the research program, freezing technological development by the private sector and creating pressure for further subsidy of uneconomic or immature technology. Past experience with federally operated demonstration projects in this area has had mixed results at best. This type of activity should therefore generally be avoided even if increased funding were available.

CONCLUSION

The Department of Energy appreciates the Committee's interest in the conservation and renewable energy technologies and your efforts to encourage the advancement of these important sources of energy security. However, we cannot support H.R. 4226 for the reasons discussed above. I want to emphasize that we support the development and application of conservation and renewable energy technologies. We recognize that the current status of the technologies requires a longer-term perspective regarding the development of commercial products and processes through a well developed research program and we are anxious to direct available resources to supporting the high priority research needs.

TESTIMONY TO

THE HOUSE SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

ON H.R. 4226, THE RENEWABLE ENERGY AND ENERGY CONSERVATION
RESEARCH, DEVELOPMENT, AND COMMERCIALIZATION ACT

BY MARC LEDBETTER
AMERICAN COUNCIL FOR AN ENERGY-EFFICIENT ECONOMY

June 30, 1988

Mrs. Chairman and members of the Subcommittee, my name is Marc Ledbetter. I'm testifying on behalf of the American Council for an Energy-Efficient Economy (ACEEE), a private, non-profit organization that researches and disseminates information on energy efficiency. Thank you for inviting us to testify.

During the last 10 years, federal energy conservation R&D programs have been quietly turning out remarkable new energy efficiency technologies that have reduced oil imports, helped make U.S. manufacturers more competitive, and cut U.S. energy expenses. Despite this record of success, funding for these programs has been sharply reduced during the 1980s. Federal conservation R&D spending in real dollars is now less than one third of what it was in 1980. We thus encourage you to recommend an increase in funding for DOE's conservation programs. We support H.R. 4226.

1. The DOE Conservation R&D Program has been highly successful.

The achievements of the DOE conservation R&D program are far to numerous to discuss here, but the following examples indicate how successful the program has been.

DOE's lighting research program helped develop the first solid state electronic ballasts in the United States. These ballasts reduce energy consumption from fluorescent lights by 15-30%. Electronic ballasts are expected to grow from 1% of the market in 1985 to 50% in 1995. While DOE spent $2.7 million on this effort, savings to the U.S. economy are expected to reach $25 billion in the five years by which DOE advanced commercialization of the ballast -- an incredible 8,000 to 1 return on investment of federal dollars.

The federal R&D program also helped develop low-emissivity windows, which use a super thin, transparent metallic coating to block heat radiated through windows. The highly popular window is expected to comprise 50% of the residential window market by 1995. Andersen Windows, which is the largest U.S. window manufacturer, announced that low-e windows already comprise more than 50% of their sales. Low-e windows are projected to reduce U.S. energy expenditures $13 billion in the five years by which

commercialization of this product was advanced by federal involvement. This highly successful new product only cost the federal government $2 million.

The value of DOE's involvement in low-e window research is best appreciated when energy savings from the windows are compared with energy production from a typical offshore oil platform. An $8 million low-e window coating plant can coat over 20 million square feet of glass per year. When compared with standard double pane windows, low-e windows produced over the ten year life of a coating plant will save about 36 million barrels of oil equivalent, which is the same amount of energy production that can be expected from a typical offshore oil platform costing $250 million.

DOE has advanced the commercialization of many other conservation technologies, designs, and procedures. A recent DOE report entitled Energy Conservation Program Success Stories lists about 30 new commercialized technologies developed through DOE conservation R&D programs, and dozens of other major program and technical successes.

Of course not all conservation research projects have been as successful as the two described above. However, the net benefits from just the two technologies listed above outweigh all the money appropriated since 1976 for the entire conservation R&D program by more than 15 to 1.

2. Conservation R&D can help improve the competitiveness of American industry.

Federal support for development of new energy efficiency technologies is needed to improve the competitiveness of American industry. Private companies can not do much of the needed research on their own -- the risks and costs are often too high.

American industry spends over $100 billion per year on energy. Despite impressive gains in the last decade, it is far less energy efficient than most of its major foreign competitors. (See Table on next page.) Improving the energy efficiency of American industry, especially energy-intensive industries, can make U.S. industry more competitive. New energy-efficient technologies developed or under development with DOE support can sharply reduce production costs. Strip steel casting, for example, can cut energy consumption in steel plants by 32% and sharply reduce capital requirements in new steel plants. Foam processing for textiles substantially cuts energy used to process textiles and can greatly improve production rates. Impulse paper drying mechanically forces moisture out of paper, leaving less moisture that must be evaporated with energy-intensive processes. This process is expected to reduce energy consumption in a paper plant by 10% and sharply reduce fiber consumption.

Industrial Energy Use, Selected Countries

Country	1985 Industrial energy use per unit of industrial value added*
West Germany	0.18
Italy	0.23
Japan	0.21
Sweden	0.29
United Kingdom	0.24
United States	0.43

* Expressed in tonnes of oil equivalent per thousand 1980 U.S. dollars.
Source: International Energy Agency, OECD, Paris, 1987

Improving the energy efficiency of products sold by American industry is also an important means of making American industry more competitive. The vast array of industries that manufacture energy consuming equipment, like the makers of residential appliances, commercial heating and cooling equipment, automobiles, and electric motors stand at the door of an enormous international market for advanced, energy efficient products. Japanese and American industry/government teams, for example, are competing to develop gas-fired residential heat pumps, which promise to be twice as efficient as the most efficient gas furnaces available today. Products such as condensing gas furnaces and low-e glass have demonstrated that a large market exists for advanced, energy-efficient products.

3. Funding for the conservation R&D program needs to be stabilized.

Stable funding is highly important to the conservation R&D program, as it is to most any scientific research. The concern was recently addressed in a National Research Council report on DOE's conservation R&D planning process. The report stated,

> ...reduction in support for energy conservation R&D has had an adverse effect on research centers, particularly private sector contractors who may be cost sharing and who have made capital investments on the assumption of multi-year federal program commitments.
>
> Steps should be taken to stabilize the budgetary and contractual commitments to long-term research.
>
> Planning for Energy Conservation R&D
> National Research Council, 1986

Congress should take steps to stabilize funding and assure

companies that are cost sharing in DOE research projects that Congress doesn't intend to sharply shift its funding priorities from year to year. One such step is to pass an authorization bill for conservation R&D. An authorization bill states a direction and an intention that is missing in appropriation bills.

4. The federal government should recommit to conducting conservation technology demonstrations.

Technology demonstrations require researchers to apply and prove new technologies in real world situations. Small-scale demonstrations played an important role in establishing the market viability of many new technologies supported through DOE's conservation R&D program, such as solid state fluorescent light ballasts. When the ballast research program was begun in 1976, none of the major ballast manufacturers showed any interest, nor did they respond to a request for proposals to cost share initial development. However, with the cooperation of two contractors, DOE helped develop the new ballasts. The first commercial demonstration of the ballasts was conducted at Pacific Gas & Electric Company's headquarters building in San Francisco. A large number of ballasts failed in the demonstration, owing to design faults not identified in laboratory testing. A second demonstration of an improved ballast was conducted with DOE support at a Veterans Administration medical center in Long Beach, California. After this successful demonstration, the VA Office of Construction became the first federal agency to specify the use of solid-state ballasts. Several large ballast manufacturers are now making solid-state ballasts.

Federal energy technology demonstrations are often criticized because they are inherently risky and because they are often very expensive. But unlike most energy technology demonstrations, conservation technologies have the advantage of being inexpensive, so if they fail, the cost to the federal government is small.

Conservation technology demonstrations should be conducted in close cooperation with industry, which should share substantially in the cost and risk of the demonstration. As technologies are advanced and risks are reduced, the government's share of costs should decrease, or in some circumstances, eliminated. The appropriate level of cost sharing should be determined on a case-by-case basis and be influence by such factors as: the ability of a private company to share, the vested interests of the company, the residual rights required by the proposer, and the level of risk of the project to the government and the company. The government should approach demonstrations cautiously.

5. The Alternative Budget for Energy Conservation recommends increases in funding similar to the increases recommended in H.R. 4226.

Because the federal energy conservation R&D programs can boost U.S. industrial competitiveness and general economic strength, we urge this subcommittee to recommend increased funding for these programs. Our specific recommendations for increased funding are contained in the Alternative Budget for Energy Conservation, which was developed by dozens of organizations with expertise in conservation programs and technologies. (The list of organization that have endorsed the Budget is attached.) The Budget represents a sound, realistic approach to federal support of conservation programs.

The recommendations for funding were built from the ground up. Experts in conservation R&D reviewed each individual subprogram for their importance to the overall federal conservation effort, and their funding needs. Needed funding increases as well as possible savings were identified and included in the recommendations. The resulting recommendations provide a minimum base level of support for existing programs.

The table below compares the FY 1988 appropriations and the FY 1989 recommendations of H.R. 4226 and the Alternative Budget.

COMPARISON OF CONSERVATION R&D FUNDING
(in millions)

	FY 88 Approp.	FY 89 Alt. Budget	FY 89 H.R.4226
Transportation	51.8	55.1	58.0
New Initiatives		5.4	
Industry	33.1	32.6	42.0
New Initiatives		4.1	
Buildings	33.6	47.2	52.0
New Initiatives		8.7	
Multi-Sector	29.0	34.1	33.0
New Initiatives		2.5	
Policy & Management	1.7	2.4	1.6
Total	156.2	192.1	186.6

The Alternative Budget and H.R. 4226 recommend similar increases in all areas, except Industry and Policy and Management. We recommend that the FY 1989 levels in H.R. 4226 be adjusted to more closely reflect the Alternative Budget recommendations.

The Alternative Budget does not contain recommendations for FY 1990 and 1991 as H.R. 4226 does. Although we support the increases recommended for FY 1990 and 1991, which are roughly 10% per year, we suggest more aggressive annual increases. According to the Department's Multi-year Plan, the program can easily put higher increases to good use, as can be seen in the following table.

FUNDING NEEDS IDENTIFIED IN DOE'S MULTI-YEAR PLAN

	FY 89	FY 90	FY 91
Transportation	93.4	96.8	97.7
Industry	53.3	51.9	50.3
Buildings	57.3	67.4	65.1
Multi-Sector	53.5	68.7	82.8
Total	257.5	284.8	295.9

5. The Alternative Budget contains recommendations for new research initiatives that exemplify what might be done with additional funding.

New Initiative on Industrialized Housing

Sweden supports a housing technology R&D program that supports a growing industry producing high-quality, super-insulated, factory-made houses. The program has helped factory homes expand from 60% of the Swedish new housing market in 1971 to 90% in 1983. Swedish funding for this program is approximately the same as U.S. government support for building R&D even though the Swedish housing market is 1/20 as large as the U.S. market. Swedish firms are now exporting these houses around the world, including the United States. Japanese companies are also producing high-quality, factory-made houses that are being considered for export to the U.S.

Most homes in the United States, in comparison, are site built. Conservation efforts in these buildings have focused on improving building components, not on improving the construction and operation of the whole structure, an approach that can reduce energy demand by up to 60%. Thus home energy consumption remains high and expensive, and leaves the U.S. housing market vulnerable to foreign companies offering more energy-efficient factory housing.

We propose an industrialized housing program that would develop new technologies and designs that would reduce energy demand in factory-made homes to 50% of a comparable site-built house. This program would work closely with industry to develop computerized design and analysis tools for designers that treat houses as whole systems; analyze what elements of foreign industrial-built homes can be adapted to the U.S.; develop

factory quality control procedures for testing the thermal integrity of sub-assemblies; analyze what new technologies in other industries can improve industrial housing, such as engineered plastics, high strength adhesives, and flexible manufactured systems for automated assembly; and other tasks important to improving industrialized housing technology. We recommend $1.5 million for the first year of the five-year program, after which time the program will become self sufficient.

New Initiative on Advanced Windows for Automobiles

Another new initiative we recommend is advanced windows for automobiles. Recent styling changes in automobiles have increased the use of glass, which has resulted in greater internal heat gain from sunlight. In turn, automobile air conditioners are used more to compensate for the additional heat gain. Automobile fuel economy is consequently reduced, especially in hot climates. (About 5% of total fuel consumption in automobiles is attributable to air conditioning.) Recent advances in windows indicate there is significant potential for controlling heat gain in passenger vehicles. These advances include windows that 1) transmit only the visible portions of sunlight; 2) reject high angle sun but allow the driver to see through them, and 3) have switchable optical properties (like photochromic sunglasses). These technologies can reduce solar heat gain (which will allow downsizing of air conditioners) and substantially reduce the amount of fuel used by air conditioners. Japanese car companies have already introduced some of these features in 1989 car models.

An excellent opportunity exits to apply the results of a successful 10 year research investment in buildings glazing to automobile cooling problems. Proposed new research efforts include:

1) Development of a multi-year research plan with participation of industry.

2) Development of a simulation tool to predict auto performance with various glazing options.

3) Conducting basic materials research to develop the technology base for industry to develop advanced glazing materials. (This would build upon the related window research already supported by DOE for building applications.)

CONCLUSION

We recognize the need to reduce the federal deficit makes it difficult to justify increased funding for any program. However, R&D is basic to the health of the U.S. economy and the ability of the U.S. to compete in international markets. Given this nation's massive energy bill (approximately $460 billion annually), energy conservation's track record of helping to keep this bill down, and the enormous potential for further reductions in energy use, increased funding for energy conservation R&D is a wise investment for this country, even in times of tight federal budgets. We therefore encourage this subcommittee to work for increases in the conservation R&D program.

Organizations Endorsing the Alternative
Energy Conservation Budget for FY 1989

ALLIANCE TO SAVE ENERGY

AMERICAN ASSOCIATION OF RETIRED PERSONS

AMERICAN COUNCIL FOR AN ENERGY EFFICIENT ECONOMY

AMERICAN FEDERATION OF STATE COUNTY AND MUNICIPAL EMPLOYEES

AMERICAN GAS ASSOCIATION

AMERICAN INSTITUTE OF ARCHITECTS

AMERICAN PUBLIC POWER ASSOCIATION

CONSUMER ENERGY COUNCIL OF AMERICA

CITIZEN/LABOR ENERGY COALITION

ENVIRONMENTAL ACTION

ENVIRONMENTAL DEFENSE FUND

ENVIRONMENTAL POLICY INSTITUTE

FEDERATION OF AMERICAN SCIENTISTS

FRIENDS OF THE EARTH

NATIONAL AUDOBON SOCIETY

NATIONAL ASSOCIATION OF REGULATORY UTILITY COMMISSIONERS

NATIONAL ASSOCIATION OF STATE ENERGY OFFICIALS

NATIONAL ASSOCIATION OF STATE UTILITY CONSUMER ADVOCATES

NATIONAL COMMUNITY ACTION FOUNNDATION

NATIONAL CONSUMERS LEAGUE

NATIONAL WILDLIFE FEDERATION

NATURAL RESOURCES DEFENSE COUNCIL

PUBLIC CITIZEN

RENEW AMERICA PROJECT

SIERRA CLUB

U.S. PUBLIC INTEREST RESEARCH GROUP

UNITED METHODIST CHURCH, BOARD
OF CHURCH AND SOCIETY

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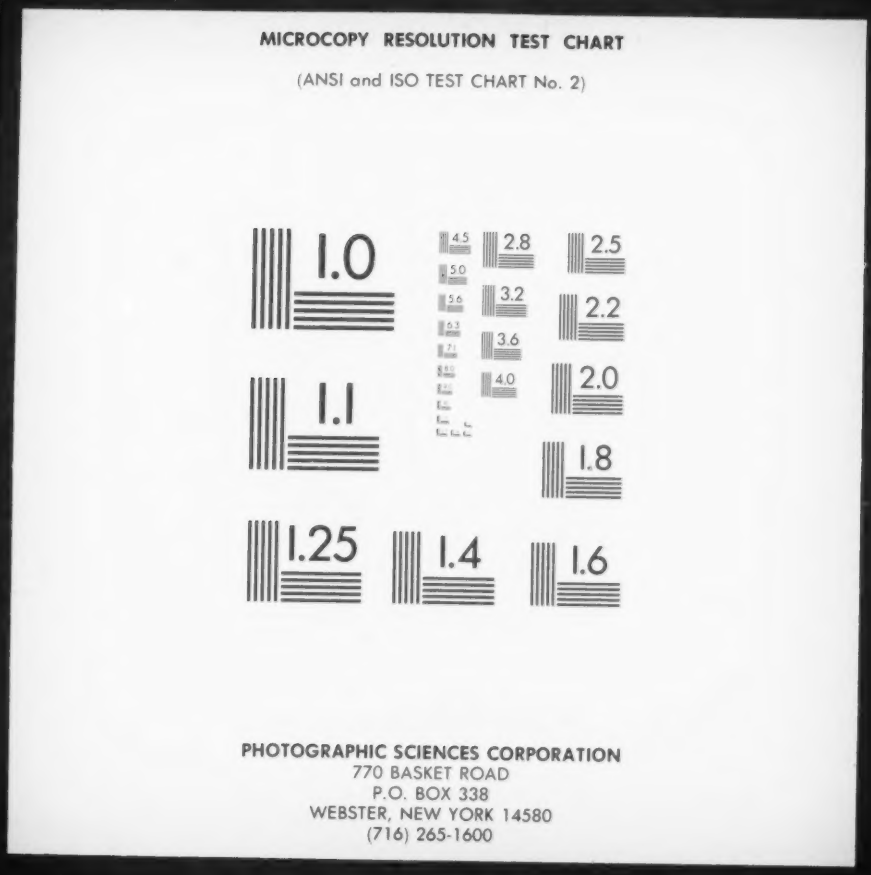

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